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CATALOGUE

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OF THE

HISTOLOGICAL SERIES

CONTAINED IN

THE MUSEUM

OF

THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

VOLUME I.

ELEMENTARY TISSUES OF VEGETABLES AND ANIMALS.

LONDON:

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PREFACE.

THE Council of the College of Surgeons, sensible of the advantages which have been derived, and are likely to accrue, from the employment of the Microscope in the study of Anatomy, Physiology and Pathology, have formed, under the name of the Histological Series of the Museum, a Collection of Preparations of the Elementary Tissues, both healthy and morbid, of Animals and Vegetables, adapted to illustrate the results and uses of microscopical investigation.

The Council deem it worthy of notice, in connexion with the manifold obligations which science owes to John Hunter, that the nucleus of this series, consisting of 150 specimens, prepared by William Hewson, constitutes an original portion of the Hunterian Collection. But it was in the year 1841 that the Council were first enabled to prosecute effectually the design which they had conceived of aiding and encouraging the use of the Microscope; and with this view they purchased the Collection of the late Dr. Todd of Brighton, consisting of 1558 specimens of Comparative Anatomy, Natural History, and Pathology. Having thus far succeeded in securing the foundation of the Histological Series which they proposed, they next obtained by purchase, in the year 1846, 2500 specimens of the Elementary Tissues of

Plants and Animals, prepared by Mr. Quekett previously to his appointment as the Assistant Conservator. In the ensuing year, Mr. Quekett commenced the arrangement of the new series with a view to its explanation and description, and in order to supply the want which had become apparent in the progress of his work of systematic continuity and scientific completeness adequate to the contemplated purposes of the collection, his labours were directed to this scarcely less than indispensable aim, and their result was the addition to the Collection of 1280 specimens. The Council desire also to acknowledge the liberality of various Donors, whose valuable contributions have further enriched this department of the Museum; and they have the satisfaction of announcing that the Histological Department now contains no less than 6838 Preparations, forming a collection calculated to meet the most pressing needs of the student of Microscopical Anatomy.

The Council, in pursuance of their plan of providing the main requisites for instruction in this branch of scientific inquiry, and having had the good fortune to secure the services of Mr. Quekett, whose eminent ability in microscopical researches is universally acknowledged, had the satisfaction of appointing him in the year 1844, to deliver annually a Course of Demonstrations, with a view to the exhibition and connected description of the Collection, and to the explanation of the method and resources of microscopical study.

The Council have subsequently entrusted to Mr. Quekett the responsible duty of preparing, under the superintendence of the Museum Committee, the Catalogue, Descriptive and Illustrated, of the Histological Series. The Volume now published contains the description of 404 specimens of the Elementary Tissues of Vegetables, and of 762 specimens of those of Animals. The Plates, eighteen in number, are the representations of upwards of 400 of the preparations described

in the text; and each figure has been faithfully copied from the microscope by means of the Camera Lucida, under the inspection of Mr. Quekett. In the arrangement of the Vegetable Tissues, the classification adopted is a modification of that followed by Dr. Lindley in the last edition of his "Introduction to Botany;" and in that of the Animal Tissues, the classification, with such alterations only as are necessary to include the tissues of the lower animals, is in accordance with the Tabular View, presented by Professors Todd and Bowman in their work entitled "Physiological Anatomy."

In conclusion, the Council observe that each Division of the Catalogue is introduced by some prefatory observations, intended to direct the attention of the student to the principal points of interest, which the specimens therein described will be found to exhibit, and to the character, anatomical, physiological, or pathological, of the class of objects from which they have been obtained; but that in these general observations all hypothetical opinions have been avoided, and such statements only admitted as Mr. Quekett's experience has enabled him to verify.

June 13th, 1850.

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HISTOLOGICAL CATALOGUE.

PHYSIOLOGICAL SERIES.

Division I.

HISTOLOGY OF VEGETABLES.

Series I.

Membrane.

VEGETABLE physiologists are now generally of opinion that, with the addition of an intercellular organic mucus or *cambium*, all plants are made up of an elementary membrane, existing in the form of cells or utricles, the basis of which consists of a tough insoluble material called *cellulose*.

Membrane when first formed is thin, transparent and structureless, often more or less coloured and always destitute of visible pores, although fluids readily pass through it. In those cells of which the walls are studded with dots having the appearance of holes, the membrane is sometimes so excessively thin that its presence is with difficulty detected, unless the specimen be slightly charred, or tincture of iodine be applied to it, both of which operations cause the membrane, however delicate, to assume a brown colour. An exception however must be made to the walls of old or dead cells: in these the membrane has sometimes disappeared and a hole is left, as shown in Plate II. fig. 11, *a. b.*

In the process of growth the thin membranous cell-walls become thickened by the deposition of new matter either on their external or internal surface, more

frequently the latter. The deposit is termed secondary, and is said to occur generally in a spiral form. On the walls of old cells and of those formed in tissues, hereafter to be described under the name of the *hard* or *gritty*, such as the stones of the plum, peach, cherry, &c., this deposit is named *Sclerogen* by Turpin. It may occur either in a homogeneous form or in concentric strata, so as nearly to fill up the whole interior of the cell, as shown in Plate I. fig. 3; or certain passages or canals may be left, as in Plate III. figs. 10, 11, 12, all of which communicate directly with the central cavity of the cell, but in no case do their free extremities open into or anastomose with the canals of adjoining cells, the cell-wall always forming a boundary between them.

a. *Structureless membrane.*

A 1. A portion of a delicate transparent membrane taken from the outer surface of a seed of a Gourd; it is composed of fusiform cells of which the walls are extremely thin and transparent, but exhibit no trace of structure.

A 2. A portion of the pulp of a ripe *Pear*, exhibiting a number of cells of different sizes, the cell-walls being composed entirely of a structureless membrane.

b. *Coloured membrane.*

A 3. A vertical section of the root of a Fern, *Pteris aquilina*, exhibiting many cells, with walls of a rich brown colour; some of these may be noticed as occurring singly in the midst of other cells of which the walls are colourless.

c. *Dotted or pitted membrane.*

A 4. Cells obtained from the pith of the Elder, *Sambucus nigra*, with walls minutely dotted.

A 5. Portions of the roots of a *Marchantia*, which consist of elongated cells with walls exhibiting angular and rounded dots upon their surfaces.

A 6. A portion of woody fibre of the Alder, *Alnus glutinosa*, enclosing a large duct divided longitudinally; the duct is of the dotted kind, and when seen under a power of 1000 diameters, shows that the membrane is not perforated in any part, either in or around the dots. Plate II. fig. 10 *c*.

A 7. A vertical section of a Pine, *Pinus Strobus*, the ligneous cells of which have bordered pores or glands ; these under some aspects appear perforated in their centre with a small hole, but this specimen, which has been slightly charred, exhibits the continuity of the membrane over the supposed hole.

d. *Deposit of new matter on the internal surface of membrane.*

A 8. A transverse section of a scale of a cone of the *Pinus Webbiana*, exhibiting numerous cells cut across their short diameters; these exemplify the thickening of the membranous walls of cells by the deposition of new matter within them. Plate III. fig. 12 *b*.

A 9. A longitudinal section of a scale of a cone of the *Pinus Webbiana*, exhibiting a mass of cells divided across their short diameters ; these also exemplify the thickening of the membranous walls of cells, by the deposition of new matter within them ; a large cavity is still left, from which branches or tubes extend even as far as the wall of the cell. Plate III. fig. 12 *a*.

A 10. A transverse section of Snakewood, *Brosimum guianensis*, exhibiting some old ligneous cells, with their cavities nearly filled up with secondary deposit ; one of these is shown in Plate I. fig. 3 *a*.

A 11. A transverse section of the Beech, *Fagus*, in which are numerous old ligneous cells thickened by concentric strata of secondary matter ; many of them are of a rich brown colour.

A 12. A transverse section of a fossil Palm from Antigua, exhibiting many bundles of ligneous cells, all of which are more or less thickened by a deposit of secondary matter in concentric strata. Plate I. fig. 6 *b*.

e. *Deposit of new matter on the external surface of membrane.*

A 13. A portion of a hair from the fornix of the corolla of the *Anchusa italica*, exhibiting a deposit of tubercles of new matter on its external surface ; each tubercle contains two or more cavities, and a defined margin exists between them and the hair to which the tubercles adhere as so many scales.

A 14. A portion of the cuticle of an Aloe, *Aloe verrucosa* ; it consists of a layer of more or less hexagonal cells with thick walls ; their outer surfaces are

tuberculated, there being a large tubercle in the centre of most of the cells, and a number of very minute ones all over the surface. In addition to these are other larger tubercles visible to the naked eye, and situated on the outer surface of the membrane, which consist of masses of cells raised above its general level. Plate I. fig. 6 *c*.

f. *Perforated membrane.*

A 15. A vertical section of the stem of a Balsam, *Balsamina hortensis*, exhibiting many large vessels, originally porous, but by the absorption of the membranous cell-wall each pore has been converted into a hole. Plate II. fig. 11 *a*.

Series II.

Fibre.

Fibre, although formerly considered elementary, is now admitted to be a secondary deposit, never developed separately, but always in the interior of cells. It is solid, and either transparent or of a greenish white or red colour. Its direction is most frequently spiral, though sometimes found straight. It varies considerably in size; in the cells of the *Pleurothallis ruscifolia*, as seen in Plate I. fig. 4, it is large, each fibre being about $\frac{1}{3000}$th part of an inch in diameter; in other plants it is much more minute, as seen in figs. 9 and 12, and resembles hair of the most delicate kind. In some cases fibre is found loose in the interior of cells; in others it adheres not only firmly to the cell-wall, but even two or more neighbouring fibres will grow together and produce a variety of appearances, such as rings, dots, reticulations, &c. on the surfaces of cells. Fibre is also sometimes branched, and, like membrane, is frequently increased in thickness by the continuation of the deposit of *sclerogen* on its internal surface, by which means a delicate thread may be converted into a solid band, as seen in Plate III. fig. 8.

B 1. A series of fibres from spiral vessels, obtained from the bulb of *Scilla maritima*, and freed from any investing membrane; when stretched they become straight, but speedily again take on the spiral form when the force of traction is removed.

B 2. Cells from the seed of the *Cobæa scandens*, exhibiting a very delicate spiral fibre coiled round in their interior; in those cells that are ruptured the fibre is seen unrolled, and its size can then be measured.

B 3. Cells from the leaf of an orchidaceous plant, *Pleurothallis ruscifolia*, exhibiting a very large flattened spiral fibre in the interior of the cells. This preparation is represented in Plate I. fig. 4, and the fibre is there shown unrolled; the diameter of one of these is about $\frac{1}{3000}$th of an inch.

B 4. Cells obtained from the testa of the seed of the *Collomia grandiflora* by moistening it with water, when a very delicate transparent cell is thrown off from the testa by the action of a spiral fibre within it. This preparation exhibits both the delicacy of the membrane and the spiral direction of the minute fibre enclosed within it.

B 5. Cells obtained from the testa of the seed of a *Salvia*, in which both the membrane and the fibre are more extensively developed. Some of the cells of this seed are represented at *b* in Plate I. fig. 9.

B 6. Elaters of a species of *Jungermannia*, consisting of two more or less flattened spiral fibres, of a beautiful red colour, wound closely together; the membranous cell-wall within which they are enclosed is not well shown:—Plate I. fig. 8 *e*. The diameter of these fibres is on an average $\frac{1}{500}$ of an inch.

B 7. Leaves of a Moss, *Sphagnum*, which consist of a series of undulating thick-walled cells, having the delicate spiral fibre within them. Plate I. fig. 6 *a*.

B 8. Hairs obtained from the testa of the seed of *Acanthodium spicatum*; these exhibit a delicate membrane, enclosing a very minute spiral fibre, which readily unrolls on the application of fluid. Plate IV. fig. 3.

B 9. Spiral vessels obtained by maceration from an Opuntia, *Opuntia vulgaris*; the membranous cell-walls are destroyed, and the fibre, which is on an average $\frac{1}{600}$ of an inch in diameter, is unrolled and free.

B 10. Vessels obtained by maceration from an Opuntia, *Opuntia vulgaris*, in which the fibre, originally spiral, has, by a deposit on its inner surface, become thickened into a flattened band, and in some parts forms a ring resembling a quoit. Plate III. fig. 8.

Series III.

Cellular Tissue or Parenchym.

The most simple plants are composed of a closed cell or utricle, and all the others, however complicated in structure, are made up of a series of such cells, variously modified and arranged according to the conditions under which they are developed and the functions they have to perform. All cells consist, when young, of a delicate more or less transparent membrane entirely closed. Their typical form is either oval or spherical, as seen at *a*, Plate I. fig. 1, but by mutual pressure in growth they acquire more or less of the dodecahedral shape, as shown at *b* in fig. 1. The cell-walls are perfectly destitute of any pores or openings; but in some plants are more or less *dotted* or *pitted*, the pits being depressions on the inner surface of the delicate membranous wall, which may be readily seen under a magnifying power of at least 400 diameters, after the application of tincture of iodine, or the charring process before alluded to. In pulpy fruits, such as the strawberry when ripe, the cells may be readily separated one from the other; in many fruits and plants the agency either of boiling water, of acids or of maceration is required to effect the separation. The walls of the cells are transparent, and generally either colourless, or more or less tinged with green or brown. The varied colour of the corolla of flowers does not depend upon the colour of the cell-wall, but on the contents of the cells themselves, as may be seen in preparations E 3 and 4. The largest cells are found in aquatic plants; but in the gourd tribe and in the pith of the elder they attain a great size, in the gourds varying from $\frac{1}{50}$ to the $\frac{1}{600}$ of an inch. When a thin transverse section of cellular tissue is made and examined by the microscope, it presents a honeycomb appearance, as seen in fig. 2 *a*, the cells having a hexagonal figure, separated from each other by partitions; but the elongated shape, which is regulated by pressure of the adjoining cells, may be seen by a vertical section, as in fig. 2 *b*. A delicate membrane, termed the primordial utricle by Mohl, exists in the interior of the walls of young and growing cells; and within the cell itself is a nucleus or cytoblast, with sometimes a smaller cell or nucleolus within it. Plate I. fig. 1 *a*. The contents of cells are

various, most commonly green or other colouring matter in the form of granules, starch and crystals, termed Raphides, as seen in Plate II. figs. 1, 2, 3, 4, &c.

According to Valentine and Röper, the wall of each cell of several species of the genus *Sphagnum* is perforated near the top, the hole, according to the latter observer, being sufficiently large to allow the entrance and escape of certain animalcules of the genus *Rotifer*.

Subseries I. *Typical Cells.*

C 1. A portion of Yeast, consisting of very minute oval cells with nuclei, which are known as a fungus termed *Torula cerevisiæ*; it is one of the most simple forms of plants and is very rapid in its growth, the process of fermentation depending on the more or less rapid development of these cells. A plant belonging also to the genus *Torula*, and very like this in appearance, is found in diabetic urine when fermentation commences, hence it has been named *Torula diabetica*. Plate I. fig. 1 *c*.

C 2. A portion of the pulp of a ripe *Strawberry*, exhibiting numerous cells of a spheroidal figure separated from each other; some of them, when first taken from the fruit, were full of reddish fluid, but all trace of this is now lost.

C 3. A portion of the pulp of a *Raspberry*, exhibiting cells of various shapes and sizes, some spheroidal, others oval, whilst by far the greater number are much elongated; all of them, when first taken from the fruit, were full of a beautiful crimson fluid.

C 4. A portion of the pulp of a *Peach*, exhibiting numerous detached cells; the smallest are of spheroidal figure, whilst the larger ones are more or less elongated; some of the latter will even be found fusiform in shape, and resembling very much the pointed hairs on the cuticle of many plants.

Subseries II. *Forms of Cells.*

It has been previously stated that the typical form of the vegetable cell is spheroidal, but when developed under pressure other shapes result according to the direction in which the pressure may be applied; hence arise the forms

known to botanists as the oblong, lobed, square, prismatical, cylindrical, fusiform, muriform, compressed, sinuous, stellated, filamentous, &c.

D 1. A vertical section of the stem of the *Equisetum fluviatile*, exhibiting numerous oblong cells. Plate I. fig. 2 *b*.

D 2. A vertical section of the stem of a Balsam, *Balsamina hortensis*, exhibiting the oblong form of cell.

D 3. A vertical section of the leaf of a white Lily, *Lilium candidum*, exhibiting near its lower edge the lobed form of cellular tissue. Plate I. fig. 1 *e*.

D 4. A portion of the cuticle of the *Vallisneria spiralis*, exhibiting the square form of cellular tissue.

D 5. A vertical section of the stem of a Balsam, *Balsamina hortensis*, exhibiting the prismatic form of cellular tissue.

D 6. A portion of a branch of *Nitella flexilis*, exhibiting at one extremity a series of long cylindrical cells, in which during growth an active cyclosis or circulation was visible.

D 7. A transverse section of the stem of *Rumex Hydrolapathum*, exhibiting many cylindrical hairs projecting from its outer margin; these consist of a single elongated cell, jointed only at that part by which it is attached to the cuticle of the stem. The large triangular openings are divided air-cells; the circular ones nearer the centre are the mouths of vessels, around which the cells of the cellular tissue are smaller than in any other part of the section.

D 8. A portion of a transparent membrane found on the outside of the seed of a Gourd, exhibiting a layer of cells pointed at both ends, known as the *fusiform* variety of cellular tissue.

D 9 A vertical section of a Pine, *Pinus Strobus*, showing the medullary rays, which exhibit the tissue known as the *muriform*, from its resemblance to bricks in a wall.

D 10. A portion of the cuticle from the under surface of the leaf of a white Water-lily, *Nymphæa alba*, exhibiting numerous compressed cells, with some few hairs of a triradiate figure lying upon them.

D 11. A portion of the cuticle from the upper surface of the leaf of an Oleander, exhibiting cells so compressed as to appear to be only a single membrane.

D 12. A portion of the cuticle from the under surface of the leaf of a Campanula, exhibiting an aggregation of sinuous cells, amongst which may be observed numerous stomata.

D 13. A portion of the cuticle from the under surface of the leaf of a Periwinkle, *Vinca minor*, exhibiting a mass of beautifully sinuous cells, with stomata amongst them.

D 14. A portion of the cuticle from the under surface of the frond of a Fern, *Polypodium vulgare*, exhibiting a curious arrangement of sinuous cells.

D 15. A portion of the upper cuticle of the sepal of a Mallow, *Dianthus caryophyllus*, remarkable for the great beauty of the sinuous cells of which it is composed. Many stomata may be noticed between the walls of some of the cells.

D 16. A transverse section of the petiole of the Sweet Bur-reed, *Sparganium ramosum*, the framework of which is composed of ordinary cellular tissue, arranged so as to form hexagonal cells for air; these exhibit in some cases a septum or diaphragm composed of a layer of flattened cells, around the margins of which may be noticed six or more triangular openings or lacunæ. Plate I. fig. 7 *b*. In some of the septa the lacunæ are of small size; in others they are so far enlarged as to give the cell a stellate appearance, and the tissue so formed is known as stellate tissue. Small acicular raphides occur in all parts of the section.

D 17. A transverse section of the petiole of the Sweet Bur-reed, in which the septa of the air-cells are still present, but the lacunæ have much increased in size, and the stellate tissue is exhibited in a further stage of advancement. Plate I. fig. 7 *a*.

D 18. A transverse section of the petiole of the Sweet Bur-reed, in which the lacunæ of some of the septa are so far enlarged as to give the cells a perfect stellate shape. Plate III. fig. 2 *c*.

D 19. A transverse section of the stem of a Rush from New Zealand, exhibiting

in a remarkable manner the stellate form of cellular tissue. Plate III. fig. 2 *a*. The division between the cells is still shown by a transverse dark line on each ray of the star at *b*, *b*.

D 20. A vertical section of the petiole of *Nuphar lutea*, exhibiting a series of more or less oblong cells, amongst which may be noticed radiated bodies very much resembling the branched hairs on the exterior of the leaves of the Deutzia and other plants. One of these is represented in Plate III. fig. 2 *d*; it consists of two or more cells joined together, and appears to have been formed, like the stellate tissue of the Bur-reed, by the development of lacunæ; these cells appear to be all that remains of the tissue, forming one or more septa*.

D 21. A vertical section of the petiole of *Nuphar lutea*, exhibiting a number of the stellate cells much larger than those in the preceding preparation.

D 22. A series of filamentous cells from a large Fungus, *Boletus*; these are of great length and pointed at their extremities; many of them are branched and of a rich brown colour. Plate IV. fig. 1.

D 23. A portion of a Truffle, *Tuber cibarium*, exhibiting numerous branching, filamentous cells, similar to those of the preceding preparation.

D 24. A vertical section of a Mushroom, *Agaricus campestris*, consisting principally of delicate, filamentous cells, which are shorter and of greater diameter than those in the preceding preparation. Plate IV. fig. 2.

Subseries III. *Contents of Cells.*

a. *Colouring Matter.*

E 1. A portion of the epidermis of the stem of a Balsam, *Balsamina hortensis*, exhibiting numerous oblong cells, many of which are full of red colouring matter.

E 2. A portion of the corolla of *Salvia fulgens*, the upper surface and edges of which are covered with wavy cellular hairs, having in their interior very

* See Appendix A.

beautiful crimson colouring matter. The cells, when fresh, were entirely full, but in drying the fluid parts have escaped, and the colouring matter now is seen only at the sides and ends of the cells.

E 3. A portion of a petal of a Pelargonium, exhibiting cells full of beautiful crimson colouring matter.

E 4. A transverse section of the Dragon Palm of Teneriffe, *Dracæna Draco*, consisting of a series of cells, many of which are full of beautiful crimson colouring matter: some of these cells are aggregated together, whilst others occur singly in the midst of colourless cells.

E 5. A portion of the leaf of *Vallisneria spiralis*, exhibiting a number of small oval granules of chlorophylle in the outer or cuticular layer of cells.

b. *Starch.*

Starch is an universal constituent of vegetables; it occurs in the form of granules of various sizes, having definite and peculiar characters in different plants: the granules are more or less of an oval figure, and have at one extremity a circular spot termed the *hilum*, around which numerous concentric striæ are arranged, as shown by *b c*, Plate II. fig. 1. Starch plays a similar part in the economy of plants to that of fat in animals: it is soluble in boiling water, and its presence readily detected by iodine*.

E 6. A portion of the common Potato, cut transversely, exhibiting numerous cells full of starch-granules.

E 7. A similar preparation from the Potato in a diseased state, exhibiting the entire absence of starch-granules in some of the cells, and in others the commencement of growth of a minute fungus.

E 8. A portion of starch taken from the Potato. It consists of numerous granules of a more or less oval figure, within which may be seen a series of circular markings somewhat like those in the cells of fibro-cellular tissue; the granules vary in size from $\frac{1}{500}$ to $\frac{1}{1000}$ of an inch. Plate II. fig. 1 *b*.

E 9. Granules of starch obtained from an Indian Bean; they are of an oval figure with peculiar slit-like markings and concentric striæ. Plate IV. fig. 5.

* See Appendix B.

E 10. A portion of Canna starch, *Tous les mois*, consisting of granules very much larger than those of the Potato, but exhibiting the same kind of markings. In this specimen they vary in size from $\frac{1}{200}$ to $\frac{1}{800}$ of an inch. Plate II. fig. 1 *c*.

E 11. A portion of starch taken from a grain of Rice. The granules are of an angular figure, and many of them as small as $\frac{1}{5000}$ of an inch. Plate II. fig. 1 *a*.

E 12. A series of cells taken from the Rhubarb, *Rheum palmatum*, most of which are full of granules of starch. Some of the cells are much elongated, others more or less oval; the latter are filled with starch-granules of large size, which are so closely packed together as to present the appearance of having angular facets. Other cells, for the most part smaller than the preceding, are present amongst them, and are occupied by stellate crystals or raphides of oxalate of lime. Plate I. fig. 5 *a*.

E 13. A series of cells taken from the Rhubarb, *Rheum palmatum*, exhibiting numerous small starch-granules, of different sizes, in their interior, the oval cells having the largest; these are so pressed together as to present a crystalline appearance, and a resemblance to the conglomerate raphides found in some of the other cells. Plate I. fig. 5 *a*.

E 14. Granules of starch obtained from the milky juice of *Euphorbia splendens*; they consist of short cylinders, with a rounded knob at each extremity, and are said to be present in all the members of this tribe of plants. Plate IV. fig. 6.

E 15. A vertical section of the tuber of a Yam, *Dioscorea*, consisting of cells full of granules of starch, similar to those in the Potato, as a substitute for which it is often used in tropical countries.

c. *Raphides.*

Raphides are crystals found in all parts of the interior of plants, and most frequently occur in the cells, but may be met with sometimes in vessels, and even loose in the anther mixed with pollen. The crystals are of various forms, the most common being the acicular and the conglomerate; the former occur

either separate or aggregated in fibrous bundles, whilst the latter are always found collected together in the form of a star. The acicular or needle-shaped crystals are composed of phosphate, the conglomerate of oxalate of lime; the shape of the former is generally a four-sided prism, but that of the latter a rectangular prism, terminated by a four-sided pyramid. The rhombohedron, octohedron and rectangular prism are sometimes found; they occur singly, and each crystal occupies a separate cell, but they are rare as compared with the two first. The term Raphides is derived from ῥαφὶς, *a needle*, as the crystals first noticed were of this shape. Their use in the economy of the plant is not known: some vegetable physiologists regard them as accidental deposits, similar to those of calculi in animals, the cause of their presence being due to the combination of certain of the vegetable acids with salts, either occurring naturally in the tissues of the plant, or conveyed into them by the sap, which itself derived them from the soil. Whether they are the result of chemical affinity or of a vital process cannot be decided, but it is certain that they may be produced artificially in the tissues of plants.

F 1. A portion of the cuticle of a Squill, *Scilla maritima*, some of the cells of which are filled with a bundle of *acicular* crystals of minute size. Near the smoothest edge may be noticed two very long cells, each containing a bundle of raphides six times as large as those above mentioned. Plate II. fig. 2.

F 2. A portion of the testa of the seed of a Grape, composed of more or less hexagonal porous cells, many of which contain raphides of the *acicular* form. The walls of the cells are much thickened, and the transverse markings on them show the depth of the pore. These raphides are said to consist of tartrate of lime.

F 3. A similar preparation, exhibiting raphides of the *acicular* form in the testa; these are also said to be composed of tartrate of lime.

F 4. A vertical section of the stem of the Vine, *Vitis vinifera*, showing alternate bands of vessels and cellular tissue, the latter abounding in starch. The vessels are of various kind, some are minutely porous, others perfectly spiral; the last, when in the living state, contained an abundance of *acicular* raphides.

F 5. A similar preparation, more thinly cut, in which the vessels and cells are more distinctly seen. The starch is absent from the cells, and their walls exhibit minute porous tissue; some *acicular* raphides are still to be seen in the vessels.

F 6. A series of cells from an Aloe, *Agave Americana*, many of which contain bundles of *acicular* raphides. Lying loose amongst the cells may be noticed other crystals, of very large size, pointed at both extremities, and $\frac{1}{50}$th of an inch in length and $\frac{1}{500}$th in breadth; each one appears to be enclosed in a cell, which may be seen projecting slightly beyond some parts of the outer surface of the crystal.

F 7. A portion of cellular tissue obtained from an Aloe, *Aloe verrucosa*, in which by the naked eye may be seen numerous silky bundles of raphides. These when examined microscopically are found to be of the acicular kind and to be contained in elongated cells. Amongst the tissue may be noticed other raphides in the shape of very short prisms pointed at both extremities; sometimes occurring singly, at others in clusters of three or four, as though a stellate mass were in process of formation.

F 8. Pollen of *Hemerocallis purpurea*, with which are seen numerous bundles of acicular raphides. This is one of the examples before alluded to of crystals occurring naked in the anther mixed with pollen.

F 9. A vertical section of the root of Rhubarb, *Rheum undulatum*, exhibiting numerous raphides of the *stellate* kind imbedded in its tissue.

F 10. Raphides of the *stellate* or *conglomerate* kind, obtained by maceration from the root of the same plant; they consist of a mass of very short rectangular prisms, each one terminated by a four-sided pyramid, this last portion of the crystal being often the only one exhibited. The composition of these crystals can be shown in many ways to be oxalate of lime, and the nature both of the acid and of the base satisfactorily demonstrated.

F 11. A vertical section of the root of *Rheum palmatum* or Turkey Rhubarb, exhibiting in its cells the *stellate* or *conglomerate* form of raphides; these are of a larger size and occur in greater numbers than in the *Rheum*

undulatum, and their presence is said to form a good criterion of the quality of the root. Some of these crystals are represented in Plate II. fig. 3 *a*.

F 12. A portion of a large Cactus, *Cereus senilis*, exhibiting an immense number of the conglomerate form of raphides. They are so abundant in the Cactus tribe as to equal if not exceed one-half of the weight of the dried tissue.

F 13. Raphides obtained by maceration from *Cereus senilis*; they consist of large stellate masses of crystals of oxalate of lime; and occurred in this plant in such numbers as to displace and almost destroy all the cellular tissue, and rendered the plant so brittle that the slightest touch produced a fracture.

F 14. A portion of the outer coat of an Onion, exhibiting in many of its cells a large octohedral crystal of oxalate of lime. Plate II. fig. 4 *a*.

F 15. Another portion of the cuticle of the same Onion, showing numerous cells containing well-marked octohedral crystals of oxalate of lime. Some of the cells contain elongated crystals and others two or more of the same kind crossing each other, as if a stellate mass were in process of formation; many of the small crystals are prisms with summits replaced by planes, whilst others rather broader are sharp-pointed.

F 16. A thin layer of the outer coat of an Onion, having bundles of very delicate prismatic crystals in each of its cells; some of these are shown in Plate II. fig. 4 *b*.

F 17. A vertical section of the flower-stalk of *Pothos coriacea*, exhibiting a large number of the acicular and conglomerate form of raphides.

F 18. A vertical section of *Polygonum orientale*, showing numerous stellate raphides in the interior of the cells. Some few of the cells contain single octohedral crystals of various size similar to those found in the Onion. This specimen also exhibits spiral vessels and dotted ducts, the fibre of the former being of large size.

F 19. A horizontal section of the same plant, exhibiting an abundance of the stellate form of raphides composed of oxalate of lime. Like the preceding

specimen, some of the cells contain small octohedral crystals. Near the outer margin large vascular bundles are cut across obliquely, and the spiral and other markings of each vessel are well shown.

F 20. A portion of the anther of *Ipomæa rubrocærulea*, in which may be observed numerous prismatic raphides intermingled with large granules of pollen.

F 21. Raphides from the bark of the Apple; they consist of small pyramidal crystals, most of which appear marked with longitudinal and transverse striæ. Plate II. fig. 6 *a*.

F 22. A vertical section of a portion of the leaf of the India Rubber Tree, *Ficus elastica*, exhibiting a cell which is said to contain a stellate mass of raphides, appended or attached to a stalk, projecting from the upper part of the wall of the cell. These bodies were first observed by Meyen, who called them *Gummi Keulen*, and are to be found in most, if not all, the species of *Ficus*. Plate IV. fig. 7*.

F 23. A portion of the inner bark or liber of the Lime, *Tilia Europæa*, which shows *raphides* of two kinds in the interspaces of the woody fibres; one kind is of a stellate form, like those in the Rhubarb and many other plants, whilst the other is prismatic and pointed at both ends; these last are seen in rows in the margins of the interspaces of the fibres, and always lie end to end. The tree from which the specimen was taken having died was cut down; the liber readily separated into thin layers, like the Lace-bark tree, and the raphides were so abundant as to fall away like a shower of dust when the bark was detached from the wood. Some of these crystals are shown in Plate II. fig. 5 *a*, *b*, *c*.

F 24. A portion of the testa of the seed of the Elm, *Ulmus campestris*, consisting of a series of cells which contain small prismatic raphides. Some of these are represented in Plate II. fig. 6 *b*.

F 25. A vertical section of the stem of *Elæagnus angustifolia*, showing an abundance of very large prismatic raphides in the interior of cells between the bundles of woody tissue. This specimen exhibits numerous ducts of small size, and elongated cells containing granules of starch; the

* See Appendix C.

walls of all the cells are minutely porous. Some of the raphides are represented in Plate II. fig. 5 *d*.

F 26. A series of small prismatic crystals obtained from the bark of the Hickory, *Carya alba*; these are pointed at both extremities, and resemble in shape and situation those of the Lime-tree, F. 23.

F 27. A vertical section of the bark of the Hickory, *Carya alba*, exhibiting raphides lying in rows between the woody fibres; they are precisely similar to those of the Lime-tree before alluded to.

F 28. A portion of the tissue of *Opuntia cochinellifera*, containing numerous stellate raphides of very large size; these are remarkable for the great distance to which the individual crystals project from the central point of attachment, and for the delicacy of the crystals themselves.

F 29. A slice of *Æschynomene* (Rice paper), in which are seen conglomerate raphides of oxalate of lime, produced artificially, the paper having been first soaked in lime-water and afterwards in a solution of oxalic acid.

F 30. A vertical section of fossil coniferous Wood from Canada, in which the ligneous cells are occupied by masses of crystalline matter like conglomerate raphides.

F 31. A tangental section* of the same Wood, showing the ligneous cells occupied with the crystalline masses, each of which has a dark central nucleus.

F 32. A horizontal section of the same Wood, in which the crystalline masses are observed; they occupy those parts where the tissue has been broken down.

F 33. A transverse section of the stem of *Cactus Opuntia*, consisting of a series of cells, each one of which is occupied by a stellate bundle of raphides; the cells are distinctly seen on the outside of the mass of crystals.

F 34. A vertical section of the stem of *Cycas revoluta*, consisting principally of small oblong cells which contain abundance of starch-granules, mingled with minute raphides of an octohedral figure; many of the starch-granules are angular and very much resemble some of the smaller crystals.

* By a tangental section is meant one made at right angles to the medullary rays, the vertical being parallel with them.

Series IV.

Fibro-cellular Tissue.

This tissue, as its name implies, consists of cells having walls composed of two structures, viz. membrane and fibre; some authors include under the same head cells consisting of fibre only. Fibro-cellular tissue exists largely in the aërial roots and leaves of some orchidaceous plants and in the leaves of many mosses, especially those of the genus *Sphagnum*; it also occurs in the pith of a few plants and as a distinct coating to several varieties of seeds. The lining membrane of the valves of many anthers exhibits the most remarkable forms of this tissue.

According to Dr. Willshire, a spiral appearance may be given to cellular tissue notwithstanding the entire absence of any spiral structure, the effect being due to the fibres of the different layers crossing each other obliquely; and when two layers, one upon the other, are examined a netted appearance is produced, with sometimes a dot or pore between each mesh.

a. *Membrane and Fibre combined.*

G 1. A portion of a Moss, *Sphagnum*, the leaves of which consist of a series of cells having a delicate spiral in their interior. The edges of the cells are slightly porous, and between them small green granules may be observed. On the inner wall of the cell, in the interspaces of the fibres, may be seen some globular markings. Plate I. fig. 6 *a*. The fibre at the point of connexion with the thickened wall of the cell appears to be slightly expanded. In *Sphagnum* the presence of a spiral was first observed by Moldenhauer in 1779.

G 2. A horizontal section of the leaf of an orchideous plant, *Pleurothallis ruscifolia*, which exhibits in a well-marked form the tissue known as *Fibro-cellular*. On the edges of the specimen the true structure of the cells can be readily examined; some of them are torn across, and the fibres to a certain degree unravelled are plainly shown to be in the interior of the cell. Numerous particles of starch are scattered amongst the cells; they are small, and for the most part of a roundish figure. When

the back of the preparation is brought into focus, the cuticle investing the under part of the leaf is readily seen, the stomata being scattered with apparent regularity over the whole surface. Plate I. fig. 4.

G 3. A similar preparation, with the fibres rendered less distinct by the great abundance of very minute granules, which appear to occupy the interior of the cells and to give to the fibre a beaded appearance: in some parts of the preparation, especially on the edge nearest the number, several cells may be seen with the fibres partly unrolled, and many of the granules, before alluded to, will be found adherent to the fibres and to the ruptured wall of the cell.

G 4. A similar preparation, exhibiting the cells and fibres as distinctly as preparation G 2. The fibres are more or less flattened, and in some cases will unroll singly, but in the majority of instances in the form of a band consisting of three or more of the fibres connected together by the membranous cell-wall. At the upper ends of some of the cells is seen the manner in which the fibres are arranged, as it were, at their commencement, and they will be noticed to begin, not from a central starting-point, but from a loop, the resemblance being very striking between this manner of disposition and that of the furrows of the cuticle at the ends of some of the fingers.

G 5. A vertical section of the leaf of an orchidaceous plant, *Pleurothallis*, exhibiting numerous cells of fibro-cellular tissue of various shapes and sizes. Immediately beneath the upper cuticle the cells are small and flat and have no fibres in their interior; below them is a layer of oval cells placed vertically, in which is a strong spiral fibre capable of being unrolled; beneath this layer is another, composed of small cells, full of green matter; still lower is found a layer of elongated polygonal cells, in which is a faint trace of spiral marking, and these are situated above a row of shorter cells, in which the spiral fibre is very apparent; a layer of small cells then occurs, and lastly the under cuticle.

G 6. A smaller section of the leaf of *Pleurothallis*, presenting similar appearances.

G 7. Cells obtained from the leaf of *Oncidium stramineum*, remarkable for their great size and for the breadth of the spiral fibre contained within them. In intimate connection with these cells are found others more delicate and transparent, and mostly of an oval shape, but without any fibre or other marking in their interior.

G 8. A series of cells from the leaf of *Oncidium Carthaginense*; they are of large size and exhibit spiral fibres in their interior, which cross each other in some parts very obliquely, and so mark out various diamond-shaped spaces. This preparation affords a good example of fibro-cellular tissue.

G 9. Cells obtained from the testa of the seed of *Cobæa scandens*: these are much smaller than the cells of the Oncidium, and are remarkable for the minuteness of the fibre and the number of spires in each cell.

G 10. Cells from the testa of the seed of *Cobæa scandens*; many of these exhibit the unrolling of the spiral fibre, which appears to have a compound character, and consists of two or more delicate filaments, forming a flattened band.

G 11. A portion of the expanded membrane or wing of the seed of *Sphenogyne speciosa*, consisting of a series of elongated flattened cells, with a delicate spiral fibre within; the walls of the cells are thickened at their points of contact and exhibit numerous pores. Plate IV. fig. 9.

G 12. A portion of the wing of a seed of *Bignonia radicans*, consisting of a layer of flattened cells with a very delicate spiral fibre in their interior: in some of the cells the fibre is continuous throughout, in others it is interrupted at certain points where a striped appearance is presented.

G 13. Two seeds of *Manethia coccinea*, which, in the expanded part or wing, exhibit a series of elongated flattened cells having a spiral fibre within: the arrangement of the latter is not so regular as is seen in the two preceding preparations.

G 14. A portion of the testa of the seed of *Maurandya Barclayana*, which is composed of a number of more or less oval cells, with a fibre in their interior. Some of the cells exhibit the continuity of the fibre throughout their whole length, in others the fibre is not continuous, but interrupted

at intervals, giving the cell-wall a striped and somewhat porous appearance.

G 15. Cells obtained from the outer surface of the testa of the Almond, *Amygdalus communis*, immediately above the dark lines or veins: they are remarkable as exhibiting peculiar pores, arranged in a somewhat spiral manner, having been at one time cells of fibro-cellular tissue in which the fibre has been broken up into dots or pores; one of these is represented in Plate II. fig. 9 *a*. The cells from other portions of the testa are without any markings, but many contain brown colouring-matter in their interior. The veins themselves consist almost entirely of spiral vessels.

G 16. Two seeds of *Lophospermum erubescens*, which are provided with an expanded membrane or wing; in this delicate part is seen a series of elongated cells, some of which contain a spiral fibre, but in others the fibre is interrupted at certain intervals and the cell rendered porous, the line of the pore being inclined at a considerable angle to that of the cell-wall. Plate II. fig. 8 *a*.

G 17. A seed of the same plant mounted in Canada balsam, in which the spiral fibres are more faintly shown.

G 18. A series of cells thrown off from the testa of the seed of *Collomia linearis*, after moistening with water; the thin delicate cell-walls inclose a large spiral fibre, which in unrolling carries the cell-wall with it.

G 19. Elongated cells thrown off from the testa of the seed of a Sage, *Salvia grandiflora*, inclosing a spiral fibre: both membrane and fibre are more strongly developed in this than in the preceding specimen. Plate I. fig. 9 *b*.

G 20. Elaters of a *Jungermannia*, which consist of elongated cells, each having two more or less flattened spiral fibres within; from having been mounted in fluid the cell-wall is shown, which is not the case in preparation B 6.

G 21. A portion of the cuticle of *Alstrœmeria ovata*, with a few elongated, flattened, jointed hairs, the walls of which exhibit markings interlacing each

other in various directions, an appearance resulting from the development of very minute fibres within the cells. Plate IV. fig. 4.

b. *Fibre without Membrane.*

G 22. A portion of the outer surface of the seed of *Acanthodium spicatum*, after moistening with water. It consists of a mass of elongated cells, having a spiral fibre within: the membranous wall of the cell is readily seen in some of the specimens, but in those in which the spiral is much unrolled, its presence can hardly be detected, so that this tissue has been classed among those exhibiting fibre without membrane. Plate IV. fig. 3.

G 23. Cells from one of the Antheridia of *Polytrichum commune*; each cell contains a spiral filament, having at one extremity an oval enlargement or head; when placed in water the filaments commence a vibratory movement, hence they have been regarded by some observers as *phytozoa*, but by others as fibre in its earliest stage of development. Plate IV. fig. 28 *a*.

Series V.

Pitted Tissue, Porous Tissue, or Bothrenchym.

This tissue consists of cells or tubes of various size, the walls of which present an appearance of being perforated with slits or pores. The shape of the pore varies considerably in different cells, and even in different parts of the same cell. In some cells the pores are uniform in their size and regular in their distribution in all parts of the cell; in others they are perfectly regular in their size and arrangement, except in those parts where the cells abut on other cells. The most common shape of the pore is circular; but they are frequently found of an oval figure, and in some cases so much elongated as to form slits, which when a number of them are arranged in a spiral manner, give to the cell a character very similar to that of a scalariform vessel. Amongst other varieties of this tissue may be mentioned one in which a spiral fibre coexists with pores; the cell then very closely resembles the glandular woody tissue of some of the *Coniferæ*, as that of the Yew, shown in Plate I. fig. 12.

The pores, as before described in pages 1 and 6, are not holes in the cell-wall,

but thinner portions of the membrane, and are occasioned by absence of the secondary deposit in those parts where they occur. The deposit is stated to take place generally in a spiral form; and when it happens before the cell has completed its growth a spiral fibre results, but if after the cell has attained its full size, a series of pores will be developed, which may be of two kinds, *simple* and *bordered*; the first is the most common, and includes all the varieties of form known to botanists as slits, dots, pits and depressions; the second, or bordered kind, much more rare, is principally confined to the woody tissue of the *Coniferæ*, and will be fully described under that head.

a. *Cells with simple pores.*

H 1. Roots obtained from a Marchantia, *Marchantia polymorpha*: these are of two kinds, one consisting of delicate but elongated structureless cells, joined end to end; the other of similarly shaped cells, with walls presenting peculiarly arranged pores, those on the margin being in form of a slit placed obliquely with respect to the side of the cell, while those in the centre are of the usual circular figure.

H 2. Roots obtained from a Marchantia, *Marchantia polymorpha*: some of them are transparent flattened cells or fibres more or less dotted, Plate II. fig. 8 *c*; whilst others, 8 *b*, *d*, are remarkable for presenting an undulated edge, as if caused by the continual twisting up, in a spiral manner, of a flattened band; this appearance however results, in a great measure, from the development of the small triangular pores described in the preceding preparation.

H 3. A vertical section of the stem of the plant *Æschynomene*, which furnishes the Chinese or true Rice paper, and consists of a series of elongated cells, the walls of which exhibit numerous simple pores. This plant affords an instance of slight thickening of the cell-wall by secondary deposit.

H 4. A vertical section of the stem of the Chinese Rice paper plant, in which the cells are of angular figure and their walls very minutely porous.

H 5. A transverse section of the stem of the same plant, showing the oval shape of the cells and the very small size of the pores in their walls.

H 6. A vertical section of the stem of the Indian Rice paper plant, *Desmanthus*

natans, exhibiting a series of oblong cells of nearly equal size; these present most delicate markings on their sides, but their flattened ends, which are somewhat lozenge-shaped, are covered with large pores; running parallel with them are square cells belonging to the medullary rays, and containing minute granules of starch.

H 7. A tangental section of the stem of the same plant, exhibiting the mouths of the medullary rays, and the minutely porous character of the sides of the cells and the well-marked pores of their ends.

H 8. A tangental section of the same plant, in which the elongated walls of some of the cells present similar pores to those at the extremities of the cells in the preceding preparation.

H 9. A transverse section of the stem of the same plant, showing the pores at the ends of most of the cells; in the majority of the other cells, which do not exhibit pores, the cell-wall is absent.

H 10. A transverse section of the stem of the same plant, exhibiting the pores in the extremities of the cells, with the occasional presence of the mouths of large vessels having a bundle of woody tubes around them.

H 11. A vertical section of the pith of the Elder, *Sambucus nigra*, consisting of cells with simply porous walls.

H 12. A transverse section of a portion of the stem of the celebrated Dragon Palm, *Dracæna Draco*, of Oratava in Teneriffe, stated to be the oldest living inhabitant of the globe: it consists of cellular tissue, in which are imbedded bundles of woody fibres; the cells are remarkable for the size and number of their simple pores, and the walls of the woody fibres are considerably thickened by deposit. In one part of the preparation the fibres are cut obliquely, and will be found to resemble very closely those in the Elder, as represented in Plate IV. fig. 19, but with the addition of dark-coloured glands or pores, as in the *Coniferæ*.

H 13. A similar section of the Dragon Palm, taken from nearer the outside or bark: the cells exhibit the same simple porous structure as the preceding, with the addition of rich crimson colouring-matter in some of the oldest cells.

H 14. A vertical section of the Vine, *Vitis vinifera*, exhibiting cells, woody fibre and vessels: the cells are all more or less porous, the pores being of the simple form and best seen where the granules of starch are absent.

H 15. A portion of the lining membrane of the testa of the seed of a Gourd, exhibiting a connected layer of more or less oval, porous cells; many of them are cut across so that their internal surface can be viewed: in some parts of the specimen the cells are arranged end to end and communicate freely with each other. Plate I. fig. 9 *a*.

H 16. A similar preparation from the testa of the seed of a Gourd, showing in a more marked degree the porous cells of which it is composed.

b. *Elongated cells or ducts with simple pores.*

In the preceding series of preparations the porous character was shown principally in the cellular tissue or parenchym; in the following series the nature of the pores, on the walls of elongated cells or tubes, termed ducts will be displayed.

H 17. A vertical section of a fossil Exogen, exhibiting about its centre a row of elongated cells or ducts, the walls of which are remarkable for the very minute size of their pores. Plate IV. fig. 10.

H 18. A vertical section of the same Exogen, in which a porous duct of similar character is seen.

H 19. A vertical section of the stem of a left-handed climbing plant from the East Indies, which is remarkable for the number and size of its porous ducts. The pores are exceedingly minute; some of them are of circular figure like those in the two preceding preparations, whilst others are hexagonal with a central marking in form of a slit which resembles that of *Piper nigrum* represented in Plate II. fig. 9 *b*.

H 20. A series of elongated cells or ducts obtained from the root of *Tragopogon pratense*, all of which present more or less of the simple porous character, the pores being of much larger size than those of the preceding specimens. This preparation also strikingly exemplifies the mode of connection of the ducts; some are sharp-pointed, and their extremities overlap those of the neighbouring ducts, others have flattened terminations and are joined end to end.

c. *Ducts with bordered pores.*

H 21. A vertical section of the root of the Alder, *Alnus glutinosa*, exhibiting the remains of porous ducts of very large size. The outer borders of the pores are of a hexagonal figure, with a more or less oblong central marking within them; they are arranged so closely together that they give to the vessel a honeycomb appearance. All the other cellular tissue in the same section has a like porous character. One of the ducts and a few of the cells are shown in Plate II. fig. 10.

H 22. A similar section of the root of the Alder, in which some of the large porous ducts are divided vertically and their internal structure displayed. This specimen can be examined with higher magnifying powers than the preceding one, when the pores present the appearance represented by *c* in Plate II. fig. 10, as viewed under a power of 400 linear.

H 23. A transverse section of the root of the Alder, showing the divided ends of the ducts, many of which, it will be noticed, have portions of the porous cell-wall adhering to them.

H 24. A vertical section of the stem of a Vine from the East Indies, which is remarkable for the porous character of all its tissues. Between the bundles of woody fibre may be observed ducts of large size with bordered pores, similar to those of the Alder shown in Plate II. fig. 10: many of the cells are full of rich brown colouring-matter.

H 25. A thinner section of the same Vine, in which the nature of the pores is more clearly shown.

H 26. A vertical section of the stem of the *Testudinaria elephantipes*, all the cells of which are minutely porous, as shown in Plate III. fig. 3. In the centre of the section the cells are more elongated, and the deposit in them is much thicker; the pores are also more numerous and of larger size, as shown at *a* in fig. 3; the walls of the cells have a beaded appearance, and are so faint in some places as to be scarcely perceptible, and the mass of cells resembles a large duct.

H 27. A vertical section of *Testudinaria elephantipes*, the cell-walls of which are

minutely porous; bundles of woody fibres occur at intervals. On either side of these may be seen elongated, characteristic, porous cells, similar to those shown in Plate III. fig. 3 *a*, having the remains of old reticulated ducts among them.

H 28. A transverse section of the stem of *Testudinaria elephantipes*, showing bundles of woody fibres and vessels. The walls of all the tissues are of the porous character.

H 29. A transverse section of the stem of the same plant, exhibiting porous cells; on one edge, the section has been made more or less obliquely, so that the walls of the elongated cells before alluded to are well displayed. Among them may be seen the remains of the old reticulated ducts, described in the vertical sections.

H 30. A vertical section of the leaf of *Zamia spiralis*, the walls of the cells of which present peculiar porous markings; some of these are of the ordinary kind, whilst others, very large and irregular in shape, are formed by spaces left unoccupied by the deposit of secondary matter; in a few of the cells the arrangement of the deposit is in form of spirals and rings. Bundles of small woody fibres and porous ducts occur between many of the cells. *Presented by J. S. Bowerbank, Esq., F.R.S.*

H 31. A vertical section of the leaf of *Zamia spiralis*, in which are shown all the characters described in the preceding specimen, but from being rather thicker the pores are not generally so well displayed.

H 32. A transverse section of the leaf of *Zamia spiralis*, showing bundles of woody tubes and vessels arranged amongst the cellular tissue; many of the cells of the latter exhibit septa; and around the margin of nearly every cell may be seen small triangular, intercellular spaces. A few raphides occur in parts of the specimen. Some of the septa show the extent of the secondary deposit in the form of small cones, which project from the sides of the cell into the interior. The walls of the woody tubes on the margin of the section are much thickened.

H 33. A vertical section of *Areca montana*, exhibiting porous cells which have

pointed extremities, and are connected together in a bundle; the pores are simple and of an oval figure. Some few large spiral vessels are present, with their fibres much thickened.

H 34. A vertical section of the stem of *Avicennia tomentæa*, exhibiting porous ducts and cells of very large size: many of the pores have a slit-like marking in the centre. The junctions occur at short intervals; some of the longest joints are uniformly marked all round, whilst others that are shorter, as well as the small cells immediately adjoining them, are similarly porous. The cell-walls of these last appear to be undergoing the process of destruction to form lengthened joints. The same process may be noticed on the sides of more narrow ducts, as if their diameter were about to be increased by the taking in of the adjacent row of cells.

H 35. A similar preparation of *Avicennia tomentæa*, exhibiting the thickness of the walls of the ducts, which appear beaded from the pores having been vertically divided.

H 36. A vertical section of the stem of *Polygonum orientale*, the cells of which have porous walls; many of these, as shown in Plate III. fig. 1, are collected together in a bundle, as though a large duct were in process of formation.

H 37. A vertical section of *Ripogonum parviflorum*, consisting of elongated, porous cells, amongst which may be seen woody fibres, also porous, like those of the Elder; both have very thick walls, in which transverse markings, indicating the depth of the pores, are visible. The most remarkable character, however, in this preparation, is that presented by the elongated cells above mentioned, which are of three principal varieties; the first exhibits oval pores, without any central markings; the second, pores so elongated as to form slits or dots, the cell resembling a scalariform vessel; whilst the third, from the extreme elongation of the pores, has the appearance of both a spiral and reticulated vessel.

H 38. A vertical section of *Ripogonum parviflorum*, which shows the same characters in the woody and cellular tissue as the preceding specimen: the ducts are of small size, and principally of the scalariform kind.

H 39. A vertical section of *Ripogonum parviflorum*, exhibiting larger ducts than the preceding preparation.

H 40. A transverse section of *Ripogonum parviflorum*, consisting of bundles of woody fibre and vessels imbedded in cellular tissue; the woody fibres are much thickened by deposit, and the radiating lines in their walls indicate the depth of the pores.

d. *Cells and ducts with pores and spiral fibres.*

H 41. A vertical section of the Laburnum, exhibiting bundles of porous cells and ducts, occurring alternately with woody fibres; the smallest cells have two or more spiral fibres crossing each other obliquely; others, rather larger, have pores in the interspaces of the spiral fibres, whilst the largest of all have numerous pores, with a portion of the fibre only adherent to their centre, and projecting somewhat beyond their outer borders. The woody fibres are slightly porous, and are crossed at right angles by numerous elongated cells belonging to the medullary system.

H 42. A tangental section of the Laburnum, in which, next to the porous tissue, the medullary rays are most conspicuous; these consist of large oval patches of thick-walled cells, surrounded by porous ones, those nearest the outer margin presenting either fibres separately, or fibres and pores, whilst the more distant cells are simply porous. The woody fibres are present only at the ends of the preparation; their extremities have been torn up in the process of cutting.

H 43. A transverse section of the Laburnum, showing the divided extremities of woody fibres and ducts; the former are of small size, and so much thickened by secondary deposit, that scarcely any trace of a central cavity remains. The ducts are very numerous, nearly of uniform diameter, and have portions of their walls still adherent. The pith is composed of thick-walled porous cells.

H 44. A tangental section of the Elm, *Ulmus campestris*, exhibiting numerous large ducts between the woody fibres; many of the ducts are remarkable for having circular bordered pores of considerable size, with a delicate spiral fibre running in some cases between the rows of pores, and in

others over them. Between many of the woody fibres small ducts or vessels may be seen, having within them a simple spiral fibre without any pores; these are most commonly pointed at both extremities. The large oval masses of divided cells, in all parts of the preparation, are the medullary rays. One of the ducts is represented at *c* in Plate II. fig. 9.

H 45. A tangental section of the Elm, showing greater abundance of ducts and vessels of both kinds than the preceding preparation; most of those that are porous are of large size, and have the spiral fibre interrupted at certain points, but chiefly over the centre of the pore, where it projects slightly beyond its outer border, giving a slit-like marking to the pore, as shown in Plate II. figs. 9*c*, 12 *b*.

H 46. A vertical section of the Elm, exhibiting both porous and spiral vessels and medullary rays in great abundance; the latter consist of elongated cells with thick walls.

H 47. A vertical section of the Elm, exhibiting the same appearances as the last-described preparation.

H 48. A transverse section of the Elm, showing the diameters of the woody tubes and ducts; to many of the latter the membranous walls are still adherent.

H 49. A transverse section of the Elm, showing the arrangement of the woody fibres and vessels; the former are thick-walled, and have the medullary rays radiating between them. The pith is also shown, and its cells are minutely porous.

H 50. A vertical section of the Lime, *Tilia Europæa*, exhibiting a great number of cells and vessels, the walls of which are remarkable for having a spiral fibre co-existing with pores; the latter are of small size, and the fibre, which is most commonly double and interlaced, has a pore in each interspace. In some of the vessels the fibres only are seen, and in these they are mostly single, and their spiral turns wide apart.

H 51. A tangental section of the Lime, *Tilia Europæa*, in which the same kind of vessels are seen, with the addition of the mouths of the medullary rays. The woody fibres are also more numerous in this than in the preceding preparation, and their walls slightly porous like those of the Elder.

H 52. A transverse section of the Lime, *Tilia Europæa*, showing the divided extremities of the cells, woody fibres and vessels; the former two exhibit pores in their walls, whilst the latter are considerably thickened by deposit, and small interspaces left between some of them.

H 53. A vertical section of the stem of the Black Pepper, *Piper nigrum*, exhibiting large ducts having very minute pores, with a short transverse line or fibre passing through the centre of each. In some parts the fibre is present and the pore altogether absent; in others the pores have a slight central marking, and are situated between the fibres; in those situations in which the wall of a duct is torn the membrane appears ragged. Plate II. fig. 9 *b*.

H 54. A vertical section of *Piper nigrum*, showing the same form of duct as the preceding specimen. In those parts where the membrane of the ducts has been torn, the edges are as it were fringed or toothed by the projection of the fibre beyond the membrane.

H 55. A transverse section of *Piper nigrum*, exhibiting the divided extremities of the same ducts, which are arranged as so many radii between bundles of woody and cellular tissue, each duct having a thick margin of woody matter.

H 56. A vertical section of a fossil Exogen, probably of the genus *Piper*, from the London clay of Herne Bay, Kent, which, like the three preceding specimens, exhibits large vessels with pores of peculiar character, having a dark line or fibre passing through the centre of each: when viewed with a power of 800 linear this dark line is resolved into two lines or fibres united at their extremities, but separated from each other in the centre. In some cases these linear markings are confined to the interior of the pores; in others they project slightly beyond their margins, whilst in some few instances they are continued across two or more of the pores. Plate IV. fig. 16. The pores in this preparation are of rather larger size than those in the recent specimens, and the nature of their markings can therefore be more plainly defined.

Presented by J. S. Bowerbank, Esq., F.R.S.

H 57. A vertical section of a left-handed climbing plant from the East Indies, which presents a similar kind of porous tissue to that of the recent *Piper*; the pores of the ducts are numerous, of small size, and have the linear marking or fibre passing through their centre.

H 58. A vertical section of a fossil Exogen, exhibiting many large ducts, which originally presented characters similar to those of the Alder, shown in Plate II. fig. 10 *c*, but in which the central dot is absent in the majority of the pores, and nothing left but the outer margin; in parts of some of the ducts the dots are present, and in a few instances these are replaced by others more remarkable, which consist of two or three concentric rings as seen in cells that have been thickened by secondary deposit. Plate II. fig. 12 *a*. *Presented by J. S. Bowerbank, Esq., F.R.S.*

H 59. A vertical section of a fossil Exogen, exhibiting large ducts which were originally of the porous type, but probably from decomposition the central part of the pore has been destroyed, and the thickened margins now only remain; in some parts however the central marking is present, and proves that the ducts belong to the porous class. Plate II. fig. 11 *b*.

Series VI.

Woody Tissue or Pleurenchym.

This tissue, which forms almost the entire bulk of certain plants, consists of elongated, transparent, membranous tubes of great strength, varying considerably in size in different plants; each tube is pointed at its extremities, and its walls are perfectly destitute of openings. Plate I. fig. 8 *a*, *b*. Numbers of tubes are aggregated together in bundles, and are readily distinguished from all the other varieties of cellular tissue by their length and great toughness; in some cases they are so attenuated and thickened internally by deposit of new matter as to have received the name of fibres from many botanists.

In by far the greatest number of examples no markings occur on its surface, but in some plants, as shown in Plate I. fig. 8 *c*, it is covered with minute, simple pores, and according to Lindley, in *Oncidium altissimum* has tubercles on

its surface. But the most remarkable form of woody tissue occurs in the *Coniferæ*, in which the tubes are provided with one or more rows of bordered pores, termed by many botanists discs or glands; this has led to the division of woody tissue into the simple and the glandular. The glands, as shown at Plate I. fig. 12, sometimes exist in conjunction with spiral fibres.

The true nature of the bordered pores or glands in the *Coniferæ*, as well as those belonging to porous tissue in general, will be fully exemplified hereafter. In some cases the tubes contain starch, and in others the walls are thickened by a deposit of successive layers in their interior.

In those parts of a plant, where much tenacity is required, woody tissue always exists; this property renders it eminently calculated for being manufactured into linen.

a. *Simple woody tissue.*

I 1. A series of woody fibres obtained from the stem of *Canna bicolor*; they consist of very delicate, flattened, structureless tubes, pointed at both extremities and aggregated together in bundles, Plate I. fig. 8 *a*, *b*: they vary considerably in their length, so that in the majority of them both ends cannot be seen in the same specimen.

I 2. A series of woody fibres obtained from *Clematis vitalba*; they are pointed at both extremities, vary considerably in length, and some have a few small roundish granules adherent to their outer wall.

I 3. Woody fibres taken from Flax, *Linum usitatissimum*, in the raw state in which they are arranged in bundles; where a fibre is isolated, it consists of a delicate cylindrical tube without any trace of pores.

I 4. Woody fibres taken from Flax, after the first operation of hackling, in which the bundles being broken up the individual fibres are isolated. They are perfectly cylindrical and transparent, but at certain intervals exhibit the appearance of a knot or joint, as if each tube were composed of a series of cells. The diameter of the fibres varies from $\frac{1}{200}$ to $\frac{1}{1000}$ of an inch.

I 5. Woody fibres taken from Flax, after the operation of bleaching. No material difference is to be observed between this specimen and the preceding,

excepting that the fibres are rather more transparent, and the transverse markings or joints, before alluded to, more plainly exhibited.

I 6. A transverse section of the stem of Flax; it consists of a ring of woody tubes, varying considerably in diameter, and having very thick walls arranged in a radiated manner round a central portion of cellular tissue or pith. This last, in the larger portions of the stem, is torn across, and the stem itself is then hollow.

I 7. A portion of the woody tissue of a plant, known in commerce as the China Grass; it consists of two kinds of fibres, one of large size, the other still larger, but composed of bundles of exceedingly delicate fibres firmly adhering together, so that each bundle appears at first as an individual fibre, but when examined microscopically its true nature is seen.

I 8. A portion of China Grass, after the first operation of hackling; by this process the large fibres are distinctly shown, and the bundles are more or less separated, but still their elementary fibre can only occasionally be seen in an isolated condition.

I 9. A portion of China Grass, after the operation of bleaching; the large fibres generally are rendered more transparent and glassy, and some of the bundles of the very minute fibres are much reduced in size; but neither this process nor that of hackling has separated the bundles into their ultimate elements.

I 10. A vertical section of the lower part of the stem of the China Grass plant, which resembles that of the *Æschynomene*; it consists of cellular and woody tissue, both of which are more or less porous. The greater part of the specimen is composed of little else than small oblong cells, with occasional rows of similar cells presenting porous surfaces; on either side of these are seen the woody fibres, which consist of more or less flattened tubes pointed at both extremities, and having very minute pores in their walls; these fibres are on an average not more than $\frac{1}{50}$ of an inch in length, and occasionally both ends may be seen in the field of view at one time, it would therefore appear from this specimen that the very beautiful silken fibres composing the grass cannot be obtained from the lower part of the plant.

I 11. A series of fibres of the Flax Bush of New Zealand, *Phormium tenax*; they consist of bundles of exceedingly minute tubes, as in the China grass, but the elementary fibres are of a size intermediate between those of the China grass and those of the Flax, *Linum usitatissimum*. One of these bundles is remarkably tough when pulled in a straight line, but readily breaks when bent at an angle. In this specimen the ultimate fibres vary from $\frac{1}{200}$ to $\frac{1}{800}$ of an inch.

I 12. A series of fibres obtained from the common Pine-Apple; they consist of bundles of very delicate woody tubes, most of which are of smaller diameter than those of flax, but contain a much larger cavity; they are also shorter, and their ends more sharp than those of any of the fibres met with in the preceding specimens.

b. *Woody tissue with simple pores.*

I 13. Woody fibres obtained from the root of the Elder, *Sambucus nigra*; they are more or less flattened in the middle, with thick rounded edges and pointed extremities; the central part is more or less transparent and marked with simple pores, whilst the edges, which abut on those of other fibres, are also porous, and the transverse lines upon them indicate the depth of the pore in those situations. Plate IV. fig. 21.

I 14. Woody fibres obtained from the Elder, exhibiting the same appearances as those described in the preceding preparation, and also the disposition of the fibres in bundles.

I 15. A transverse section of the root of the Elder, exhibiting the short diameter of the woody fibres, which have very thick walls, occasionally marked with delicate lines indicating the pores; between the fibres are seen the openings of large ducts, and radiating from the centre the small elongated porous cells, which are arranged in a double row, and answer to those of the medullary rays in other plants.

I 16. Woody fibres obtained from the petiole of *Zamia pungens*; they vary much in size, and each is composed of a series of elongated, slightly brown-coloured cells joined together, the points of junction being indicated by

transverse septa; in those parts where the fibres inclining to each other form an oval space, numerous stellate raphides may be observed.

I 17. A vertical section of the flower-stalk of *Loasa contorta*, exhibiting woody fibres of considerable length, all of which are more or less dotted. Among these may be noticed ducts presenting the same character in a more marked degree.

I 18. A vertical section of the flower-stalk of *Loasa contorta*, exhibiting elongated cells and ducts, all of which are more or less dotted; among them are a few spiral vessels.

I 19. A series of fibres obtained from the thick outer margin or wing of *Bignonia stipularis*; they are of considerable length and have pointed extremities, and principally occur in bundles.

When an ultimate fibre is dissected from the bundle, as may be seen in many parts of this preparation, its walls present peculiar markings: in some specimens pores are seen, in others a trace of a spiral fibre, whilst in the greater number the centre is free from pores, but the margins exhibit a beaded appearance.

I 20. A vertical section of *Ephedra alata,* composed entirely of woody fibres and cells; the latter belonging to the system of the medullary rays and having minutely porous walls. These do not form a layer above the woody fibres, but are continuous with them; the woody fibres have chiefly minute dots, but here and there may be seen a large fibre, with two or more rows of circular pores, somewhat like those in the *Coniferæ*, but without any central dot; in other fibres are rows of pores, each pore having a slight marking in its centre, which appears to project above its surface; many of the smaller fibres also have pores with similar markings.

I 21. A tangental section of *Ephedra alata*, exhibiting the large openings of the medullary rays and the woody fibres with their pores and glands; the large pores, few in number, are divided vertically, and they appear to occur chiefly at the pointed extremities of the woody fibres.

I 22. A tangental section of *Ephedra alata* made nearer to the bark; the medullary

rays, cellular tissue and woody tubes are well shown; many of the cells contain small granules of starch.

I 23. A transverse section of *Ephedra alata*, showing the medullary rays, which consist of cells arranged more or less obliquely, but radiating between the woody fibres; the central portion is occupied by the pith, the cells of which have minutely porous walls.

c. *Woody tissue with bordered pores or glands.*

This form of tissue occurs in greatest abundance in the *Coniferæ*, of which tribe of plants it was formerly considered characteristic, but in the subjoined series of specimens it will be seen that it exists also in plants of other families. The nature of these pores or discs, as they have been termed, has long been subject of controversy; by some persons they have been supposed to be glands; others have considered them to be either thick or thin places in the membranous cell-wall of the fibre, whilst some few have stated that there is a hole in the centre of each disc, communicating with a similar hole in a neighbouring fibre. It is now however ascertained that these bordered pores are not peculiar to one fibre, but are formed between two, contiguous to each other, and always exist in greatest numbers on those sides of the woody fibres parallel to the medullary rays. They are hollow; their shape is bi-convex, and in their centre is either a small circular or oval spot, Plate IV. fig. 20; the latter may occur singly, as in fig. 20; or may be crossed by another at right angles, which gives the appearance of a cross. Sections of wood that have been made in a vertical direction and parallel with the medullary rays, afford no good idea of the nature of these markings, but sections made in the tangental direction, or at right angles to the preceding, will best reveal their true structure. In a specimen of this kind, as shown at Plate IV. fig. 19, where *a* and *b* exhibit the walls of two contiguous woody fibres, it is seen that certain oval spaces, *c c*, occur between them; these have in their centre a canal, *d d*, extending through the entire thickness of the wall of the fibre, but closed with a membrane on its outer margin, so that there is not any hole communicating with that in the adjoining fibre, as has been imagined. Those pores with an oval mark in the centre, have the long diameter of the oval inclined at an angle of 45° to the sides of the fibre, while the corresponding marking in the contiguous pore has

a similar inclination but in an opposite direction, so that if in the section the markings in two cells be in focus at the same time, a crucial appearance is presented. Plate IV. fig. 25. That the above description of the nature of these pores is correct may be proved by Preparation I 61, represented in Plate I. fig. 11 *a*. In this specimen, casts in flint of the pores are found; these are either loose, as at *b*, or adherent to the outer wall of the fibre, as at *c*. When viewed with a power of 200 linear, these casts are seen to be of a biconvex figure, with a slight projection from their centres, corresponding to the size of the small canal in the walls of the woody fibre, so that they are perfect representations of the true shape of the bordered pores as they existed in this specimen of wood.

Although in the majority of plants the pores are hollow, yet in a few instances solid spherical bodies may be seen in similar situations, and when these are removed a lenticular cavity within which they were contained may be observed. Plate I. fig. 11 *e*.

Under the head of Porous Tissue, preparations of the Elm, Lime, &c. are described, in which a spiral fibre exists with pores; in woody tissue an analogous structure also occurs in shape of large bordered pores, with one or more spiral fibres interlacing each other in various directions. Plate I. figs. 11 *a*, 12.

I 24. A vertical section of Apple-tree, *Pyrus malus*, consisting chiefly of woody fibres of small size, in some of which a row of bordered pores may be observed, each pore having a delicate central marking; between the bundles of woody fibres are numerous porous ducts.

I 25. A vertical section of Pine, *Pinus Strobus*, which was charred previous to mounting in Canada balsam. The woody fibres exhibit large bordered pores, with a circular central spot. Plate IV. fig. 20. The cells crossing the woody fibres at right angles belong to the system of the medullary rays.

I 26. A tangental section of the *Pinus Strobus*, showing the medullary rays and the pores vertically divided. On examining the walls of many of the woody fibres, such an appearance as that represented by Plate IV. fig. 19, is found; the oval cavities, *c c*, being the divided pores, and *d d* the small canals communicating with them. The large openings, arranged

in form of an oval, which are very abundant, are the mouths of the medullary rays.

I 27. A transverse section of the same Pine, exhibiting the short diameters of the woody fibres and their mode of arrangement. In the walls of many of the fibres are seen small oval interspaces, which are the glands divided transversely, their shape being very similar to that shown in the vertical section.

I 28. A vertical section of Winter's Bark, *Drimys Winteri*, exhibiting woody tissue, in each of the fibres of which two or more rows of bordered pores are seen; these are of small size and present central markings, some of which are of circular, others of oval figure. The medullary rays cross the woody fibres at right angles; in many of the cells, of which they are composed, numerous granules of a brown colour are observed. The specimen was charred previous to mounting in Canada balsam. Plate I. fig. 10 *b*.

I 29. A vertical section of a fossil wood allied to the *Coniferæ*, from Kennawha, Ohio, in which three or four peculiar kinds of structure occur; but the only one here requiring notice is that of the woody tissue, which is remarkable for having three or four rows, or even in some cases the whole breadth of each fibre occupied by large pores without central markings. Plate IV. fig. 18. The woody fibres cross each other obliquely, and at the point of crossing the pores are most plainly seen. When many pores occur their shape is either five- or six-sided, as before described in Preparation H 21.

I 30. A tangental section of the same wood, exhibiting the pores divided through their short diameters, from having no central markings; these pores present only an oval figure, the canal in their centre being obliterated.

I 31. A transverse section of the same wood, exhibiting the woody fibres divided through their short diameters with the pores in their walls; many of the fibres are filled with crystalline matter, not very unlike in shape to raphides.

I 32. A vertical section of *Cycas revoluta*, consisting of cellular tissue and woody fibres; some of the former are filled with rounded granules of starch,

others with a large prismatic crystal. The woody fibres exhibit two or more rows of bordered pores, each having an angular slit in its centre, and, when that of the under surface of the tube is brought into focus, the two combined resemble the letter X, as shown in Plate IV. fig. 27.

I 33. A vertical section of *Cycas revoluta*, exhibiting the cellular tissue and woody fibres; the latter are broader than in the preceding specimen, and present three or four rows of bordered pores of the same character as in that specimen.

I 34. A tangental section of *Cycas revoluta*, made near the outer surface; the woody fibres have no pores, but all the cells between the bundles are occupied with starch-granules and raphides.

I 35. A tangental section of *Cycas revoluta*, exhibiting the woody fibres divided in a direction at right angles to those of the preceding specimens; the walls are thickened, and the shape of the interior of the pores, which is oval, with a slit more or less inclined to the sides of the tube, is seen.

I 36. A transverse section of *Cycas revoluta*, exhibiting alternate radii of woody fibres and cells, the latter being occupied with crystals, and granules of starch.

I 37. A vertical section of *Salisburia adiantifolia*, composed entirely of woody fibres having peculiar markings; in some of the fibres are bordered pores like those in the *Coniferæ* generally, with a small circular spot in the centre; in others the spot appears to be composed of two small oval pores arranged in form of a cross; in the remainder only one oval spot is seen, which is inclined at an angle of about 45° to the sides of the tubes, and is best seen at the points where the medullary rays cross. The crucial appearance results, as shown in Plate IV. fig. 25, from the oval pores, both the upper and under surfaces of contiguous fibres being in focus at the same time.

I 38. A tangental section of *Salisburia adiantifolia*, exhibiting woody fibres and the openings of the medullary rays; the former show a few pores, divided in the same way as those in the preceding specimen; but on their walls may be seen other pores, also divided through their short diameters,

by which their internal shape may be made out; this appears to be oval, with a minute canal on each side, as shown in Plate IV. fig. 35.

I 39. A transverse section of *Salisburia adiantifolia*, showing the walls of the woody tubes considerably thickened by deposit in their interior.

I 40. A vertical section of fossil wood from Tasmania, allied to the *Coniferæ*, and exhibiting woody fibres occupied by several rows of bordered pores, as in I 29; these are most numerous in those fibres which are situated nearest the medullary rays.

I 41. A vertical section of a fossil coniferous wood from Tasmania, exhibiting woody fibres, in some of which are no bordered pores, in others only a single row of small size, whilst in the broadest as many as five rows are seen.

I 42. A vertical section of a fossil coniferous wood from the Durham coal-field, which is remarkable for the large size of the woody fibres and bordered pores; these last are of oval figure and occupy the entire breadth of the fibres; they occur in the greatest abundance in the short fibres in the neighbourhood of the medullary rays.

I 43. A transverse section of the same wood, exhibiting the short diameters of the woody fibres, in many of which are seen the remains of the divided pores projecting into the cavity of the fibres.

I 44. A vertical section of fossil wood from Australia, converted entirely into pure silica, whereby it is rendered transparent like glass; in most of the fibres are two or more rows of bordered pores, in some of which there is an appearance of concentric striæ; many of the cells of the medullary rays and a few of the fibres are occupied with minute granular matter; none of these exhibit pores.

I 45. A portion of the same wood, which is remarkable for splitting up into ultimate woody fibres having a silky lustre, much resembling those of asbestos. Each fibre has two or more rows of bordered pores of large size; but in many specimens the pores are absent, and their place occupied by concentric rings of agate.

I 46. Another portion of the same wood, consisting of a series of woody fibres completely agatized; the pores are absent, but the beautiful series of concentric rings of agate render the specimen very striking. Plate IV. fig. 36.

I 47. A vertical section of fossil coniferous wood from Tasmania, exhibiting woody fibres with bordered pores; in some parts only one row of pores is found, but in others two, three, and even five rows occur; these may be seen in the short fibres situated near the medullary rays.

I 48. A tangental section of the same wood, exhibiting the mouths of the medullary rays and numerous bordered pores, divided both through their long and short diameters; some of them are even seen in the same position as in the vertical section. All the woody fibres are of brown colour marked with diagonal lines, occurring in some places very close together, as if the specimen belonged to a species of *Araucaria*.

I 49. A transverse section of the same wood, in which the short diameters of the woody fibres are shown; in many of these the internal surface presents a more or less crenated edge, occasioned by the pores on their walls projecting into the central cavity.

I 50. A vertical section of fossil coniferous wood from Lough Neagh, Ireland, the fibres of which present rows of bordered pores of large size; in some of the fibres four rows may be seen, whilst others have but a single row. Many of the fibres exhibit no trace of pores, but are occupied by dark, oblong masses, which fill up their entire breadth.

I 51. A tangental section of the same wood, exhibiting the mouths of the medullary rays and the bordered pores divided in the direction of their short diameters. The black masses before alluded to are very abundant in this specimen.

I 52. A transverse section of the same wood, showing in a very marked manner the divided pores on the walls of the woody fibres. In some cases even an entire pore may be seen still adherent to the inner surface of the fibre.

I 53. A vertical section of coniferous wood from the Craig Leith quarry near Edinburgh, the woody fibres of which exhibit many rows of small bor-

dered pores, entirely filling the cavity of the fibre; in some parts the interior of the pore is destroyed, nothing remaining but the outer wall; the fibre there appears to have a series of spirals in its interior.

I 54. A transverse section of the same wood, exhibiting the woody fibres divided in the direction of their short diameters; they are of large size and have very thick walls, in which the pores are visible.

d. *Woody tissue with projecting bodies or glands.*

It has been already stated (page 38), that bundles of woody fibres were sometimes met with in which small spherical bodies arranged in a linear series were found projecting beyond the outer margin of each bundle, and as this peculiar structure has been noticed in two plants of totally different families, it has been thought proper to include them under one head. These bodies most nearly approach the glands of the *Coniferæ*, and are to a certain degree analogous in structure to the discs described in Preparation I 61, and represented in Plate I. fig. 11 *a*.

I 55. A portion of the leaf of an orchidaceous plant, *Aporum anceps*; it consists principally of the cuticular layer, upon the attached surface of which bundles of woody fibres may be seen; these present peculiar markings or discs, somewhat similar to those found in the *Coniferæ*, but without the central spot or pore; many of the bundles project beyond the edge of the cuticle, and in these the discs are best seen; they are composed of small circular and apparently solid bodies attached to the outer side of the fibres and inclosed by a membrane, which in some cases is elevated over them. Many delicate cells with granular contents are seen attached to the bundles of fibres; these granules, however, are perfectly distinct from those projecting from the outer edge of each bundle.

Presented by J. S. Bowerbank, Esq., F.R.S.

I 56. A similar but thinner preparation of the leaf of *Aporum anceps*, exhibiting more plainly the cells of the cuticle, the stomata and the bundles of woody fibres *in situ*; these last all show the peculiar discs on their outer surfaces.

I 57. Woody fibres obtained from the interior of the leaf of *Aporum anceps*, which

exhibit very clearly the glandular bodies projecting like those shown in Plate I. fig. 11 *d*, from the outer margin of the woody fibres, and like them also sometimes seen detached. The membrane of the woody fibres appears thickened around the discs in form of a ring, and on the opposite side of the fibre to that showing the discs in linear series, the membrane presents an undulated appearance, which is perfectly unconnected with the numerous cells adherent to the fibres. Plate I. fig. 11 *e*.

I 58. A vertical section of the Date Palm, *Phœnix dactylifera*, exhibiting vessels, woody fibres and cellular tissue; the first consist of porous ducts and spiral vessels arranged between bundles of woody tissue, which last present on their outer edges a row of small circular projections or glands like those in *Aporum anceps*, represented in Plate I. fig. 11; these are not constant upon the entire length of the fibres, but are interrupted at intervals; in only a few instances are the glands found upon the central fibres. The vessels are chiefly porous; a few spiral ones are present, having the fibre of large size. The walls of all the cells have numerous minute pores upon their surfaces.

I 59. A vertical section of the Date Palm, in which the bundles of woody tubes are of greater breadth, and exhibit the same kind of glands in different parts as those of the preceding specimen.

I 60. A transverse section of the Date Palm, exhibiting bundles of woody tubes and vessels mixed with the cellular tissue; the former are considerably thickened by deposit on the inner surface of their walls.

I 61. A portion of fossil coniferous wood from Fredericksburg, Virginia, North America, which, like Preparations I 44, 45, is remarkable for splitting up into ultimate woody fibres; one row of discs is found upon each fibre; they are much larger than those in the Australian specimens above alluded to and exhibit more plainly the marking in their centre; but the important point connected with these discs is their projection from the outer wall of the fibre, like those of *Aporum anceps*, or of their detachment from it (Plate I. fig. 11 *a*, *b*). These discs are siliceous, and appear to be perfect casts of the interior of the little cavities or pores occurring

between two contiguous woody fibres, as for instance those shown in Plate IV. fig. 19 *a*, *b*. In many of the woody fibres are no discs, but in all there are very delicate spiral markings.

Presented by Prof. J. W. Bailey, West Point, New York.

I 62. A tangental section of the same fossil coniferous wood, in which are seen the mouths of the medullary rays, and in some cases the pores in the walls of the woody fibres divided through their long diameters; in those parts of the specimen in which the arrangement of the fibres is somewhat disturbed, the discoid bodies previously described may be found lying within some of the fibres, having been detached from their original situation. *Presented by Prof. J. W. Bailey.*

I 63. A vertical section of the same fossil wood, exhibiting in some parts the discoid bodies lying upon the fibres in their natural situation, whilst in others the structure of the wood has been so much broken up and decomposed that all trace of them is lost.

Presented by Prof. J. W. Bailey.

e. *Woody tissue with spiral fibres.*

Delicate fibres arranged in a spiral manner are sometimes found in the interior of woody tubes: in a few instances the fibre is much thickened, and a flattened band, also arranged spirally, occurs in the same situations; the fibres may be met with separately, as in Plate IV. fig. 32, or large bordered pores, as in Plate I. fig. 12, may be present with them; this latter form of tissue is very common in many recent and extinct plants known as *Araucariæ*, various species of which are abundant in a fossil state in the coal districts of this country.

I 64. A tangental section of wood said to be of the common Elder, which exhibits woody tubes of small size with delicate fibres arranged in a spiral manner in their interior: between the bundles of tubes small porous cells and ducts are seen, with here and there the mouths of the medullary rays.

I 65. A tangental section of the same wood, in which the medullary rays, woody fibres and cells are more plainly shown.

I 66. Fragments of coal obtained from the Durham coal-field, composed almost

entirely of woody cells, in which are two flattened spiral bands interlacing each other at regular distances and leaving small angular spaces between them. Plate IV. fig. 33.

I 67. Woody fibres obtained by maceration from a species of *Araucaria*; these are of two kinds; one of a large size and dark brown colour, in which are seen two spiral fibres interlacing each other at regular distances; the other, much smaller and more transparent, also exhibits traces of fibres, but between them are small bordered pores.

I 68. A vertical section of fossil wood, bought at Palermo, but said to have been obtained from Greenland: it consists of short woody fibres, in the interior of some of which are flattened bands interlacing each other in such manner as to leave a series of more or less triangular spaces, arranged in a row one above the other: in some few of the fibres the bands appear interrupted at certain points and the fibre then resembles a dotted vessel. Plate IV. fig. 17.

I 69. A series of fibres obtained from a fossil wood from Fredericksburg, Virginia, being a portion of the same wood as Preparation I 61: every fibre has delicate spirals of very minute size in its interior, but the cases are rare in which the discs occur attached to the outside of the woody fibres, as represented at Plate I. fig. 11 *a*.

I 70. A series of fibres of a fossil wood found at Northfleet, Kent, exhibiting spiral fibres in their interior, some of which interlace each other so as to leave large triangular spaces resembling pores.

f. *Woody tissue with spiral fibres and pores.*

I 71. A vertical section of the Yew, *Taxus baccata*, in which are seen large woody tubes having two spiral fibres interlacing each other at regular intervals; in the interspaces large bordered pores or glands occur. In those parts of the tubes nearest the medullary rays it occasionally happens that two pores are found in one interspace, as shown in Plate I. fig. 12. This specimen is of dark colour and was found at the distance of twelve feet below the bed of the Thames at Woolwich, but all the parts of its structure can be as well seen as in the recent wood.

I 72. A tangental section of the Yew, *Taxus baccata*, exhibiting the woody tubes with their fibres interlacing, and between their walls the pores divided vertically in the direction of their short diameter. The openings of the medullary rays are of small size and very numerous.

I 73. A vertical section of the Norfolk Island Pine, *Araucaria excelsa*, exhibiting the glandular form of woody tissue with the existence also of spiral fibres. The glands are of large size and show the central dot or pore very distinctly; in some of the woody tubes are two rows of glands, in others only one. Plate IV. fig. 26. The spiral fibres are very delicate and their turns much more numerous than in the Yew, as shown in Plate I. fig. 12; in some parts, where the woody fibres are very compact and where no glands are present, rounded bodies may be observed very like those in *Aporum anceps* (Preparation I 56).

I 74. A vertical section of a smaller branch of the Norfolk Island Pine, *Araucaria excelsa*, in which are seen woody tubes with glandular pores and spiral fibres; the latter are present in every tube, but the pores, which are of smaller size than those in the preceding specimen, are abundant in those fibres contiguous to the medullary rays, but absent in most of the others.

I 75. A tangental section of the same wood, exhibiting the woody tubes with their spiral fibres; between their walls are seen the discs divided through their short diameter, together with the openings of the medullary rays, which are numerous and of large size.

I 76. A transverse section of the same wood, showing the short diameter of the woody tubes, to the walls of some of which the fibres and glands are still adherent.

g. *Woody tissue thickened by secondary deposit.*

I 77. A transverse section of a fossil Palm from Antigua, exhibiting woody cells considerably thickened by concentric layers of secondary deposit, which fill nearly the whole diameter of the fibre, a small cavity only being left in the centre. Plate I. fig. 6 *b*.

I 78. A transverse section of the petiole of *Hoya carnosa*, exhibiting woody tubes

the cavities of which are in a great measure filled up with secondary deposit. Numerous pores are seen in the walls of the tubes. Plate IV. fig. 8.

I 79. A transverse section of the petiole of *Hoya carnosa*, in which are seen woody tubes nearly filled up with secondary deposit in form of concentric laminæ, the number of which far exceeds those in the fossil Palm from Antigua, represented in Plate I. fig. 6 *b*.

I 80. A transverse section of the petiole of a *Xanthorrhœa*, or Black Boy of New Zealand; the outer margin consists of woody tubes, the cavities of which are entirely filled up with secondary deposit.

I 81. A transverse section of the stem of the Cocoa-nut Palm, *Cocos nucifera*, in which may be observed bundles of black woody fibres; their interior is entirely filled up with secondary deposit.

Series VII.

Vascular Tissue or Trachenchym.

This consists of elongated cells or tubes with membranous walls, having a spiral fibre within them; from their great resemblance to the air-tubes in insects, they have been termed *Tracheæ*. The tubes are generally pointed at each extremity, but in some cases they end abruptly, and not unfrequently are branched. The spiral fibre is always situated within the tube and is generally wound to the right, but in some plants left-handed spirals are found. In young spiral vessels the spirals are in close contact with each other, and as the cell elongates they become more or less distant; the individual fibres of the spirals are also sometimes found grown together, or separated in form of rings; modifications of these modes of arrangement produce many varieties of markings in the walls of vessels. When a spiral vessel is torn across, the fibre, by reason of its elasticity, unrolls. In some cases it is single and is called a simple spiral; in others, many fibres running in the same direction form a band, which in contradistinction is termed a compound spiral; and in a few instances the individual fibres composing the band are kept together by other minute fibres running at right angles with them, as shown in Plate III. fig. 4 *a*, *b*, *c*. The nature of the fibre

was for a long time the subject of much dispute, many observers having described it as tubular, others as solid, which latter opinion is now generally received.

Spiral vessels always terminate in conical extremities, the membrane of the cell being extended in all cases beyond the fibre. Like woody tissue, they often occur in bundles, and generally the vessels are in various stages of development in each bundle, as shown in Plate III. fig. 9 *a*, in which may be seen the gradual transition from a spiral, having the turns close together, to one in which they are detached, or so far separated as to present a series of rings. Spiral vessels in the early stages of their development are filled with fluid, but in process of growth this is sometimes absorbed and replaced by air, which is said to contain seven or eight per cent. more oxygen than the atmosphere; it would appear however that the latter condition is more or less accidental, for if these vessels be examined in their natural or growing state they may be distinctly seen to contain fluid, and thus the asserted analogy between their function and that of the tracheæ of insects is more apparent than real.

Under the head of vascular tissue are included other membranous tubes, in which the arrangement of the fibre has been considerably modified in disposition, both by the more or less rapid elongation of the cell-wall and by the growing together of the turns of the spiral; vessels then result which are known as the annular, reticulated, scalariform, &c.; all these are capable of being unrolled, and may be considered as modifications of the true spiral vessel. Elongated tubes or ducts also come under the head of vascular tissue; many of these with porous walls have been already described; they differ from all the preceding varieties, inasmuch as they cannot be unrolled without breaking; in their mode of termination in pointed extremities and in their function they chiefly agree with spiral vessels.

a. *Spiral vessels with a single fibre and pointed extremities.*

K 1. Two small leaves of an orchidaceous plant, *Bolbophyllum fuscum*, each exhibiting many short spindle-shaped cells, with a spiral fibre in their interior; some of the cells are separate, others are in groups and joined end to end; many of the cells of the parenchyma are filled with bundles of acicular raphides.

K 2. A petal of the Pimpernel, *Anagallis arvensis*, of which the upper layer of cuticle has been removed: it exhibits numerous veins composed almost entirely of spiral vessels of small size, Plate III. fig. 5 *a*; they have pointed extremities overlapping those of neighbouring vessels.

K 3. A bundle of spiral vessels obtained from the testa of the Almond, *Amygdalus communis*; these are found only in the veins of the testa, which appear to be almost wholly composed of them; they are of small size, and their pointed terminations are well displayed.

K 4. A bundle of spiral vessels obtained from a Hyacinth: they are of nearly uniform size, and remarkable for the thickness of their fibre; in many places the vessels are torn across, the fibre may then be seen unrolled; its shape is flattened, and it occasionally branches.

K 5. Spiral vessels obtained by maceration from the petiole of the garden Rhubarb, *Rheum Rhaponticum*; the spiral is of the simple kind; is unrolled in many places where the membranous cell-wall has been torn across: near to the pointed extremity of some of the vessels may be noticed a small oval hole, indicating the precise spot where an adjoining vessel communicated with it.

K 6. A series of spiral vessels obtained from the garden Rhubarb, *Rheum Rhaponticum*, in which the membranous wall of the cell can hardly be discovered; all the fibres are more or less unrolled.

K 7. Spiral vessels obtained by maceration from *Opuntia vulgaris*; they consist almost entirely of short cells tapering to a point at both ends, and having a fibre of large size within them; they are arranged in bundles, the pointed end of one cell lying upon that of its neighbour; in many of the cells the membranous wall has been destroyed, so that nothing is left but large cylindrical fibres more or less unrolled.

K 8. A similar preparation, in which the arrangement of the vessels in bundles is more plainly shown; with some of them may be seen short woody fibres like those of the Elder.

K 9. A vertical section of the stem of the garden Balsam, *Balsamina hortensis*,

exhibiting two or more rows of elongated cells or vessels, pointed at both extremities and having a strong spiral fibre coiled up in their interior. The extremity of one vessel, as shown in Plate I. fig. 3 *a*, overlaps that of its neighbour.

K 10. A series of minute tubes obtained from the base of the seed of *Sphenogyne speciosa*, having delicate spiral fibres in their interior; in some of the smaller specimens the edges appear beaded, as shown in Plate IV. fig. 11 *b*, *c*; this is caused by the bending of the fibre at those parts; in many others the central cavity is very apparent. Some tubes are present having no spiral fibre within them.

K 11. A series of tubes from the base of the seed of the same plant, of rather larger size than those of the preceding specimen; many of them present a beaded appearance without showing much of the spiral fibre.

K 12. A portion of the thickened wing of the seed of a species of *Bignonia*, which, like the two preceding specimens, consists of elongated tubes having a spiral fibre within them; the edges have a beaded appearance, caused by the sudden bending of the fibre at those points.

K 13. A series of siliceous casts of the interior of spiral vessels obtained from a fossil Palm; these are composed of more or less elongated cylinders, round which are wound a single, or in some cases a compound spiral; this may be noticed as projecting beyond the other parts of the cylinder, and proves that in the recent plant the spiral fibre was within the membranous wall of the vessel. Plate III. fig. 8 *a*.

K 14. A similar preparation, in which the spiral thread is even more evident and the casts occur in bundles.

b. *Left-handed spirals.*

K 15. A vertical section of a fossil Palm from the East Indies, exhibiting bundles of spiral vessels, of which the fibre alone remains: in some of the vessels the fibre is of large size and is wound from left to right, a direction contrary to that seen in any of the preceding specimens. Plate IV. fig. 23.

K 16. A vertical section of the stem of a left-handed climbing plant from the

East Indies, in which are a few spiral vessels; in these the fibre is wound from left to right, as in the preceding preparation.

K 17. A vertical section of the stem of an Acacia, *Acacia armata*, exhibiting a few spiral vessels, in all of which the direction of the spiral fibre is from left to right.

c. *Spiral vessels with thickened fibres.*

K 18. A series of spiral vessels obtained from the flowerstalk of an Aloe; they are nearly uniform in size, and remarkable for the great breadth of their fibres. Some few reticulated vessels may be noticed amongst them.

K 19. A vertical section of the stem of a Balsam, *Balsamina hortensis*, exhibiting a bundle of spiral vessels, in which the fibre is considerably thickened and presents the appearance of a flattened band, which frequently is seen to branch.

K 20. Vessels obtained from an Opuntia, *Opuntia vulgaris*; they are remarkable for exhibiting plainly the membranous cell-wall, which is kept open by a series of spiral bands and discs; some of the former, as shown in Plate III. fig. 8, are evidently nothing more than spiral fibres converted into thick flattened bands by extensive secondary deposit, whilst the latter or discs are the same fibre in an annular form. In other parts of the preparation may be noticed spiral vessels of the ordinary kind.

K 21. A similar preparation, in which the vessels with thickened fibres occur in large bundles; in this condition their structure is not so clearly seen as in the short detached specimens which are found in many parts of the preparation.

K 22. Clusters of vessels obtained from a Melon; these consist principally of two kinds, the most common being the short broad form above-described, and represented in Plate III. fig. 8, in which the fibre is so much thickened by deposit as to form a disc; the other kind consists of smaller spiral vessels, in which the fibre is also of large size; among the cellular tissue may be noticed a considerable number of the stellate form of raphides.

K 23. A similar preparation from the Melon, in which the vessels are more separated from each other; in this case their true nature and that of the raphides also can be more clearly made out.

d. *Spiral vessels (branched).*

K 24. Spiral vessels obtained from the young flowerstalk of the garden Leek, *Allium Porrum*; these are very short and irregular in size, and remarkable for their great tendency to branch. In many of the small specimens the spiral arrangement of the fibre is very evident, and as they increase in size a reticulated character is perceptible. Plate III. fig. 5 *b*.

K 25. A similar preparation, in which the spiral vessels are more closely packed together; they are for the most part less branched than those of the preceding specimen, and many are found unrolled.

K 26. A similar preparation, exhibiting the branching of the spiral vessels; some are considerably increased in diameter at the point of bifurcation, and the spiral fibre is there interrupted, so that a reticulated character is produced somewhat resembling the structure found in some of the porous cells from the testa of the seed of the gourd.

K 27. Spiral vessels and ducts obtained from the leaf of the Mistletoe; they are of small size and, like those of the Leek, frequently branched. Some of the ducts are much elongated, and made up of cells placed end to end. The spiral vessels are shorter and are pointed at one extremity; they are intimately connected with the ducts, and with them form a reticular structure.

e. *Spiral vessels with longitudinal bands.*

K 28. Spiral vessels obtained from the stem of *Canna bicolor*; the vessels are both simple and compound, the latter being most numerous, largest in size, and also remarkable as having a series of delicate longitudinal bars running the whole length of the vessel, crossing the spiral fibres at right angles and marking out its surface into small more or less oblong spaces. Plate III. fig. 4 *d*. Many of these vessels may be seen unrolled, and no less than nine spirals occur in each band: the minute longitudinal bars

just described may be noticed as projecting beyond the edges of the spirals at *b* in Plate III. fig. 4.

K 29. A series of vessels obtained from the same plant, which exhibit other arrangements of the fibre than those described in the preceding specimen. A portion of one of these is shown at *c* in Plate III. fig. 4; it differs from the others chiefly in size and in having both longitudinal and spiral fibres (which are of uniform thickness) placed at right angles to each other, by which equal-sized oblong spaces or pores are mapped out.

K 30. A similar preparation, in which vessels of another kind are found; the spiral and longitudinal fibres being uniform in size and equally distant from each other, the spaces marked out by them are therefore nearly square, as shown at *d* in Plate III. fig. 4; although some few vessels of each of the above-mentioned forms are present, yet the last described is rarest and most remarkable.

K 31. Spiral vessels obtained from the stem of a Banana; these are of the compound form, and like those of the *Canna bicolor*, Plate III. fig. 4, exhibit longitudinal fibres which are of smaller size and much fewer in number in proportion to the diameter of the vessel than in Canna. In this specimen all the spirals are of one kind.

K 32. A vertical section of the culm of *Typha latifolia*, in which are seen vessels with longitudinal and spiral fibres, as in the preceding specimens.

K 33. Vessels obtained by maceration from the gourd of a Vegetable Marrow, which present spiral fibres crossed nearly at right angles by others of a smaller kind; the spiral fibres in some few of the vessels are large and flat, and when portions are unrolled, the ends of the ruptured longitudinal fibres are seen projecting beyond the sides of the spirals; the latter appear to be situated external to the former.

K 34. A vertical section of the stem of a Balsam, *Balsamina hortensis*, exhibiting several rows of spiral vessels with large fibres; some of these are considerably thickened by secondary deposit, and are connected together by broad longitudinal bands which do not extend farther than from one spiral to the other; by this arrangement the walls of the vessel are

marked out into square spaces; in some vessels the longitudinal bands are curved; in these cases the spaces left are of oval figure, and in other and apparently older vessels the membranous cell-wall is absorbed in certain spots, so that perforations occur at those parts; one of these vessels is represented in Plate II. fig. 11 *a*, and shows clearly that a vessel with longitudinal and spiral fibres is in a state preparatory to the complete development of one exhibiting oval or angular markings on its walls.

f. *Compound spiral vessels.*

K 35. A vertical section of the stalk of *Hedychium Gardnerium*, exhibiting a few spiral vessels having in some cases as many as nine parallel fibres in the form of a band; some of them are unrolled; these vessels are termed compound in contradistinction to those previously described, in which for the most part the fibre exists singly. In Plate III. fig. 5 *c*, *d*, is represented a vessel seen on the upper edge of the specimen in which the bands and pointed extremity are well displayed.

K 36. Spiral vessels obtained from the stem of *Canna bicolor*, which are rather smaller than those previously described; some of them are unrolled, and as many as nine fibres enter into the formation of each of the bands.

K 37. A vertical section of the stem of the garden Rhubarb, exhibiting bundles of spiral vessels of the compound kind; some of them are unrolled and have as many as six fibres in each of their bands.

K 38. A portion of a membrane or scale removed from the neighbourhood of the spore cases of an Equisetum, *Equisetum arvense*; it consists of a layer of fusiform cells, within which are two or more fibres, forming in some cases a compound spiral. Within the interspaces are sometimes seen small bordered pores, as in the Yew. Portions of three of the cells are represented in Plate IV. fig. 34. *Presented by P. B. Ayres, M.D.*

Subseries I. a. *Annular Vessels.*

Annular vessels, like those before described, consist of a membranous tube and fibre; the latter, instead of being in the spiral form, is separated into a number

of distinct rings, placed at various intervals within the tube. They are merely modifications of the spiral type, the cell-wall having grown much faster than the fibre, some of the turns of which have adhered to the membrane and become detached from the rest. That this view of the subject is correct is shown in Plate III. fig. 9 *a*, and in Preparation L 3, in which are seen vessels in various stages of development; in the younger ones the coils of the fibre are closely packed together, whilst in the older the membrane has outgrown the fibre and left it behind in form of a ring.

L 1. A vertical section of the stem of a Water-dock, *Rumex hydrolapathum*, exhibiting various forms of annular vessels; some of these are of great breadth, and the rings occur at equal intervals; others are about half the size, and their rings are considerably thickened, especially on their edges, so that in some cases they appear like the vertebræ of a fish; one of these vessels is represented in Plate II. fig. 7 *b*.

L 2. Two vertical sections of the stem of the same plant, in which are seen annular vessels of the large and small variety, described in the preceding preparation; one of the latter presents a trace of a circular opening between two of the rings; this is occasioned by a partial thickening of the membrane in the neighbourhood of the ring, whereby a large pore is left. This appearance is represented at *c* in Plate II. fig. 7.

L 3. Bundles of spiral and annular vessels obtained from the lower part of the stem of a Lettuce, *Lactuca sativa*; in each bundle are three or more kinds of spiral vessels, all exhibiting different appearances caused by the variation in distance of the turns of the spirals from each other; in the vessel on one side of the bundle the turns are nearly in close contact, whilst on the opposite side they are so far apart that rings are formed in many places. This specimen fully bears out the statement above made, that the vessel with the closest spiral turns is of later growth than the annular form. Plate III. fig. 9 *a*.

L 4. A similar preparation, obtained from the root of the Lettuce, in which a vessel of the dotted or porous kind occurs on the outer side of the spiral one, with the turns close to each other; in the former vessel the deposit

of the fibre has not been extensive enough to form spirals, but being interrupted at nearly equal intervals one of the porous type results. In many of the bundles the annular vessel is seen.

L 5. A vertical section of the flowering stem of a garden Leek, *Allium porrum*, in which is seen a bundle of small vessels very similar to those in the Lettuce; of these the two on the outer margins of the bundle are perfectly distinct from those in the middle, one being either a porous or otherwise a spiral vessel with the turns closely approximated, and the other either annular entirely or with rings in part connected by a few elongated turns of a spiral, as shown in Plate IV. fig. 12.

L 6. A vertical section of the stem of *Balsamina hortensis*, in which are shown numerous vessels of large size, each being more or less of the annular form; in some cases one of the rings is divided, in others a few turns of a spiral fibre connect two rings together.

L 7. A series of vessels obtained by maceration from a Melon; these consist almost entirely of delicate membranous tubes, kept open by fibrous rings; many of the vessels are very short and contain only two rings, whilst others are elongated, and have as many as twelve rings in some instances, as shown in Plate III. fig. 8 *a*; a broad band of thickened fibre connects two rings together. The vessels have pointed extremities, and the cylindrical form is sometimes preserved, but most frequently the membrane between the rings is slightly collapsed, showing the great use of this modification of the fibre in keeping the walls of the tube open.

L 8. Vessels of the annular form obtained by maceration from *Opuntia vulgaris*; these are more detached from each other and much shorter than those from the Melon, rarely more than six rings being ever present in one vessel; in some parts of the preparation are seen rings detached from the membrane and lying loose, as so many quoits, amongst the debris of cell-walls. Vessels from the Melon and Opuntia have been before described under the head of spiral fibre thickened, as well as in Preparations K 20, 21, 22.

Subseries II. *Reticulated Vessels.*

These are characterised by a netted appearance produced by certain variations in the arrangement of the fibre, which instead of forming perfect spirals or being separated into rings, is continuous in some places, and in others, after bifurcating, freely anastomoses, from which a series of meshes results.

M 1. A vertical section of the stem of a Balsam, *Balsamina hortensis*, exhibiting a bundle of vessels with spiral fibres of large size; in some of these the fibre is continued round the vessel in the form of a ring; in others it bifurcates and connects two contiguous rings, so that a reticulate appearance is produced. In other vessels the continuity of the fibre is interrupted at certain points, and the connecting bands being still present, another form of reticulated structure results.

M 2. A vertical section of a Palm from Ceylon, exhibiting many large vessels, which are remarkable for the delicacy of their fibre; this is sometimes arranged in a spiral form, but frequently in rings; it often bifurcates, and produces a series of reticulations. Plate II. fig. 11 *c*.

M 3. A vertical section of a fossil Palm, in which are numerous vessels with fibres arranged both longitudinally and transversely, the latter frequently bifurcating, so that a reticulate structure is presented, the meshes being in some places oblong, in others hexagonal.

M 4. A vertical section of a fossil Palm from St. Vincent's, exhibiting many forms of vessels; some of these are similar to those in the Palm from Ceylon, but the most numerous consist of transverse and longitudinal fibres, so disposed as to leave square, oblong and hexagonal meshes between them. The termination of these vessels in pointed extremities is well shown; in those parts where they overlap, the remains of thickened fibres forming the walls of numerous large perforations are seen.

M 5. A tangental section of a fossil Exogen, in which are seen a few vessels of large size; some of these were originally porous; others have the fibre arranged so as to form a series of hexagonal meshes, similar to those shown in Plate II. fig. 11 *b*.

M 6. A vertical section of a fossil Exogen from Saugur in the Deccan, in which are many large vessels, all presenting a reticulated structure; in one, in particular, oval meshes of uniform size are seen, in the others they are more or less oblong; both kinds are remarkable for the regularity of their markings.

M 7. A vertical section of the stem of a Clematis, *Clematis vitalba*, in which are numerous vessels, principally spiral, but among them are seen others in which the fibre or secondary deposit is extensive, and arranged in a net-like manner so as to constitute them true reticulated vessels.

M 8. A portion of the expanded membrane or wing of the seed of *Lophospermum erubescens*, consisting of a layer of vessels, in some of which a spiral fibre may be observed, but in others the fibre has been thickened and deposited irregularly so as to give rise to a reticulated appearance.

M 9. Vessels obtained by maceration from the Mistletoe, *Viscum album*; they are of small size, and for the most part of reticulated structure; many of them are branched, and in the dilated parts, prior to the giving off of the branch, the reticulations are best exhibited; the mode of connection of the individual vessels is also well shown.

M 10. Vessels obtained by maceration from the Leek, *Allium porrum*, which, like those in the preceding specimen, are of the reticulated variety, and not unfrequently branched; the reticulations are best seen in the broadest parts of the vessels; in the more contracted portions a spiral structure prevails. Some of the short cells in this preparation present a striking resemblance to those obtained from the testa of the seed of the Gourd, described as Preparation H 15.

M 11. Vessels obtained from the root of a Cactus; some have still their natural connections as whilst in the plant, but each presents both a spiral and reticulated structure. Portions of two vessels are represented in Plate III. fig. 1 *a*. One of them exhibits the reticulations at the end by which it is connected with the adjoining vessel *b*, but at the opposite end a spiral fibre exists capable of being unrolled; in the vessel shown at *b* a reticulated structure is presented at the point of junction, but the re-

mainder is spiral with an occasional branching of the fibre. When the fibre is single it may be readily unrolled, but when branched the unrolling cannot generally be effected.

Subseries III. *Scalariform Vessels.*

Scalariform vessels differ from any of those previously described, in consisting of more or less angular tubes, which exhibit transverse parallel markings or stripes, occupying only a portion of their circumference; the markings are generally arranged one above the other like the rounds of a ladder, hence the name *Scalariform*; in the majority of specimens the markings are situated at right angles to the long axis of the tube, in others they are inclined more or less obliquely towards it, and give to the vessel not only a spiral appearance but also a capability of being unrolled.

Scalariform vessels are found exclusively in Ferns, and although the tubes are generally angular, with the markings rarely reaching to the angles, yet oval and circular tubes sometimes occur; these occasionally present various characters which connect them with some of the forms of porous vessels before described, with which they appear identical, and like them also exhibit, in a well-marked manner, the deposit of the secondary matter on the inner surface of the membranous cell-wall.

N 1. A vertical section of the stem of a Fern, *Diplazium seramporense*, exhibiting three bundles of scalariform vessels, which are of angular figure, pointed at both extremities, and present transverse markings or stripes, in some places of uniform length, arranged in parallel lines; some of the stripes, as shown in Plate IV. fig. 22, are surrounded with a delicate border. The deposit of the secondary matter in these vessels is of some considerable extent, and plainly indicated by the structure of their walls, which appear beaded, the lines between the beads showing the depth of the deposit. All the cells and many of the vessels in this specimen are of rich brown colour; the former contain numerous granules of starch.

Presented by J. S. Bowerbank, Esq., F.R.S.

N 2. A transverse section of the stem of the same Fern, exhibiting six bundles of scalariform vessels divided obliquely, on account of the bundles, not all

being arranged in the direction of the long axis of the stem, but more or less inclined towards it. Some bundles are seen in transverse section; these show the true shape of the vessels, which is generally polygonal and not unfrequently octagonal; their walls are much thickened and exhibit in their substance dark linear markings, which are the pores; some of the bundles are short, others extend nearly the entire length of the side of the vessel. Those bundles that have been divided obliquely show very plainly that the deposit is in the interior of the vessel, and that the light spaces are occasioned by the absence of the deposit. Between many of the bundles are seen small cells full of brown colouring-matter, these are young vessels in an early stage of growth. All the cells of the parenchyma contain granules of starch.

N 3. A vertical section of the stalk of a younger Fern of the same species as the last, exhibiting many bundles of scalariform vessels; in some the markings extend across the entire breadth of their sides, in others only a portion of the side is occupied, and this by small oval pores. The structure of all these vessels is similar to that of the preceding specimens, but the brown colouring matter is much less abundant.

N 4. A vertical section of the stalk of the same Fern, exhibiting two bundles of vessels; these are of the scalariform variety, and mostly of an angular figure with short oval markings on their walls; some few show the splitting of the fibre, and from being inclined at an angle to the long axis of the vessel a spiral appearance is presented.

N 5. A transverse section of the stem of the same Fern, exhibiting many bundles of vessels, the walls of which present dark linear markings in their substance; these are the pores, and it is seen that each side of the vessel, however narrow, has its marking. The cells of the parenchyma contain starch, and some few are of brown colour.

N 6. A vertical section of the stem of a Fern, *Pteris aquilina,* exhibiting bundles of scalariform vessels of various sizes, the largest having transverse markings of great breadth; others that are many-sided have short, broad or oval pores, corresponding in number to that of their sides. The

elongated cells in the neighbourhood of the vessels are minutely porous, and their walls have a rich brown tint.

N 7. A transverse section of the stem of the same Fern, exhibiting bundles of large vessels divided in the direction of their short diameters; attached to them are seen portions of the walls of some of the vessels, these have longitudinal markings, and in many of the old vessels the membranous wall being in part destroyed, the fibre being then left free will separate into short lengths. The remainder of the section is occupied by cellular tissue, the walls of which are in some parts of dark brown colour.

N 8. A diagonal section of the stem of the same Fern, with the scalariform vessels divided obliquely, so that their internal structure may be well observed. Plate IV. fig. 30. Some have many sides, and the markings do not surround the entire inner circumference of the vessel, but consist of as many parts as there are sides. When the inner surface of one of these vessels is viewed with a power of 200 linear, it will be readily seen that the markings are produced by a deposit of short fibres within the membranous wall; and if the fibre be brought into focus, the cell-wall will be out of focus, proving the elevation of the fibre above the membrane. When the markings are oval the fibre is reticulated, as shown in Plate IV. fig. 29, which represents a portion of the inner surface of one of the vessels having oval pores.

N 9. Vessels dissected from the stem of a Fern, *Pteris aquilina*, and allowed to dry; they are of polygonal figure with small, oval, equal-sized markings on each of their sides; some of them are unrolled, this takes place generally in form of a band, as in a compound spiral vessel, but one in particular exhibits the fibre singly. If the inner surface of the unrolled band be examined, it is seen to consist of a membrane upon which the fibre is deposited in a reticulated form; when the membrane is present, oval pores are seen on the walls of the vessel, but when it is absent, as in old vessels, perforations result, as shown on a large scale in Plate II. fig. 11 *a*. Although this form of vessel is not uncommon in many Ferns, it certainly cannot belong to the scalariform class, but rather to that of the

spiral, as was pointed out by Dr. J. W. Griffith*, by whom the preparation was presented.

N 10. Vessels dissected from the stem of the same Fern and mounted in Canada balsam; they present similar appearances to those of the preceding preparation; one of them is unrolled in the middle, and a broad band with oval markings connects the two ends together.

Presented by Dr. J. W. Griffith.

N 11. Large vessels of the scalariform class obtained from the stem of a Tree Fern; they are of polygonal figure, and the sides of unequal breadth; the markings are nearly straight and correspond to the length of the sides. Although these vessels are more nearly allied to the true scalariform type than those in the two preceding specimens, they are nevertheless capable of being unrolled, and many examples occur in this preparation. The part unrolled is a band which exhibits in a well-marked manner the length of each of the sides of the vessel and the arrangement of the fibre upon them, which is more or less straight on the broadest sides, but on the narrowest inclines towards an oval figure.

N 12. Elongated vessels obtained by dissection from the stem of a Fern, *Asplenium pubescens*; they are pointed at each extremity and remarkable for the variety of their markings, which in different parts of the same vessel resemble all the principal forms of vascular tissue. At one end, as shown at *a*, Plate III. fig. 6, the scalariform type prevails, the markings are short and the figure of the vessel is polygonal; in passing towards the opposite extremity, as shown at *b*, the diameter of the vessel is increased, the markings become more numerous and much elongated transversely; in the middle they entirely surround the wall of the vessel, which last now resembles a true spiral, and if the vessel be ruptured at this point *c* the fibre will unroll; this stucture is continued nearly to the opposite end of the vessel, and gradually terminates in small oval markings *d*, similar to those seen at its commencement.

N 13. Vessels dissected from the stem of the same Fern, which are of smaller

* Annals of Natural History, vol. xi. p. 95.

size and of much lighter colour than those of the preceding specimen. They chiefly resemble the scalariform class, each vessel being of polygonal figure with short transverse markings, answering to the breadth of the sides, but not surrounding the whole interior circumference of the vessel. The greater number of the vessels are torn, and the ragged extremities, in most cases, connected by a spiral band, composed of a portion of the wall of the vessel with markings on its surface; in certain parts the edges of the band are uneven and exhibit a single fibre detached from the rest, which also has a tendency to curl, as shown in Plate III. fig. 9 *b b*. These vessels, although found in the same situation as those of the scalariform order, and in many points resembling them, must, nevertheless, be considered as modifications of true spirals.

Subseries IV. *Ducts.*

Although many vegetable physiologists describe the annular, reticulated and scalariform vessels under the name of *ducts*, it has been thought best, in the present case, to apply this term only to such elongated cells as cannot be unrolled without breaking; and as it has been shown that all the preceding specimens of vascular tissue possess this property in common, they should therefore be considered as modifications of the true spiral type. Many specimens, properly called *ducts*, have already been described under the head of *porous tissue*, to which class they were referred on account of the peculiar markings found on their walls; but as their mode of termination and other important characters have not yet been dwelt upon, these points will here be particularly noticed.

O 1. A vertical section of the root of *Cissampelos Pareira*, exhibiting a great amount of minute cellular tissue, among which may be seen many bundles of ducts with small oval-shaped pores; in some parts of the section these are of large size and their pores uniformly arranged; in others are many small vertical markings, which tend to prove that the large vessel is made up of a number of smaller ones; both kinds exhibit similar modes of termination and connection with other ducts, by more or less flattened extremities applied to the corresponding parts of the

adjoining ducts. When one of these ducts is torn it shows no tendency to unroll although the broken edge exhibits traces of the deposit of fibre.

O 2. A vertical section of the root of the same plant, exhibiting a greater number of the large ducts and their mode of junction with others, which in some cases is indicated by a transverse, in others by an oblique line.

O 3. A vertical section of recent wood, consisting principally of large porous ducts, crossed at right angles by oblong cells belonging to the medullary rays. The ducts are joined end to end, some having a transverse imperforate septum between them, whilst others have the septum either perforated in its centre or its place occupied by a few fibres arranged one above the other like the bars of a gridiron. The pores are of large size and of circular figure, with either a round or an oval dot in their centre.

Presented by Robert Brown, Esq., D.C.L., F.R.S.

O 4. A transverse section of the same wood, which, with the exception of a few thin-walled parenchymatous cells, appears to be composed entirely of large porous ducts; many of these have been cut obliquely, so that the shape of their pores is well shown. In some parts of the preparation the pointed ends of the ducts are divided, and the tissue of the septum between two adjoining ducts is seen to have more or less of the reticulated character; in others distinct fibres exist in place of reticulations, and these, after forming a hexagonal network, are continued across the vessel in parallel lines somewhat like the bars of a gridiron.

O 5. A vertical section of a fossil Palm from Saugur in the Deccan, in which are many large ducts with finely reticulated markings; all terminate in pointed extremities, and where one duct joins another, coarse fibrous bands occur, as shown in Plate IV. fig. 15; the membrane between these being absorbed, perforations are the result.

O 6. A vertical section of a fossil Palm from St. Vincent's, exhibiting numerous porous and other ducts of large size; many of them present longitudinal as well as transverse markings, and terminate in more or less conical extremities; the arrangement of the fibre at these points is coarse and

reticulate, and very frequently strong fibrous bands, somewhat similar to those described in the preceding preparation, are found at the points of junction of two ducts.

O 7. A vertical section of anthracite Coal, which is composed almost entirely of large ducts having porous walls; the pores are of an oval figure, as shown in Plate IV. fig. 13, and are arranged in parallel rows; throughout the specimen the ducts preserve a straight direction, and are of so great a length that their mode of termination cannot be seen in this preparation. *Presented by Prof. J. W. Bailey.*

O 8. A vertical section of a Stigmaria, which exhibits a bundle of ducts of great length; these are of peculiar structure, their walls presenting a reticulated appearance, produced by the continual branching and anastomosing of a strong fibre; in some parts of the specimen the ducts are arranged side by side, and there is an appearance of the fibres of one duct passing across and joining those of the neighbouring one, as shown in Plate IV. fig. 14. All the ducts are of so great a length that their mode of termination cannot be seen.

O 9. A vertical section of the root of the Alder, *Alnus glutinosa*, showing many porous ducts of large size, the walls of which are entirely covered with pores of hexagonal figure having a central marking, as shown in Plate II. fig. 10*c*. The ducts are arranged in linear series, their junction with each other takes place at an obtuse angle; sometimes a perfect septum exists between them, but in the majority of cases this partition is more or less destroyed by the absorption of the membrane; one of the septa is shown at Plate II. fig. 10*a*.

O 10. A vertical section of the stem of *Clematis vitalba*, exhibiting bundles of ducts of small size, they chiefly belong to the reticulated and porous classes; their mode of termination is more or less obtuse, and in some cases the connection of two ducts is shown by a band or septum situated at right angles to their long axis.

Series VIII.

Laticiferous Tissue or Cinenchym.

All plants having a milky juice are furnished with a system of vessels so very different in their characters from any of the forms previously described, that they have received the various names of *Vital vessels*, *Milk vessels*, *Laticiferous vessels* and *Ducts of the Latex*. For our knowledge of the existence of laticiferous vessels we are mainly indebted to the labours of Professor Schultz of Berlin, who considered them to resemble, in many points, the capillary system of animals, and the more so as a circulation could be observed in them. This supposition however has been found erroneous, modern observations having proved that the so-called "circulation" can rarely be seen in the natural condition of the plant, but only after the vessels have been divided, when by some vital contractility they rid themselves of their contents.

This tissue is composed of membranous tubes of variable diameter, which frequently branch and anastomose, as shown in Plate IV. fig. 31, so that in some instances they form a perfect network. In their interior is contained minute granular matter of dark colour termed *Latex*, which fills the tubes in some parts, whilst in others it is entirely absent, and hence often renders it difficult to trace their continuity. In some plants, as in *Ficus*, the granules are not universally present, but the contents consist of brown liquid which becomes darker after being placed in the ordinary conservative solutions.

The situation of these tubes in different plants is subject to considerable variation; they are principally abundant in the tissues about the root and in the inner layers of the bark, and when divided yield a milky and in some instances a coloured juice, which in the genus *Euphorbia* contains small masses of amylaceous matter in shape of dumb-bells, as represented on Plate IV. fig. 6. Many botanists have regarded these vessels as intercellular passages, but the fallacy of this notion is rendered apparent by Preparation P 3, in which, having been dissected away from surrounding tissues, they are seen to have distinct membranous walls, and therefore an independent existence.

P 1. A portion of the cuticle of a stipule of the India-rubber plant, *Ficus elastica*, on the attached surface of which are seen numerous large branching

vessels; some contain granular matter, others a brown, structureless substance, and some few are empty, so that it is difficult to trace the continuity of the network, which is formed amongst the ordinary cellular tissue.

P 2. A similar preparation, in which a portion of the cuticle of the opposite side of the stipule has been allowed to remain to show the thickness of this part of the plant. It exhibits bundles of woody fibres and vessels, between and sometimes parallel with which the laticiferous tissue is seen. Many more of the vessels are filled with dark matter in this than in the preceding specimen.

P 3. A series of laticiferous vessels dissected from the surrounding cellular tissue of the stipule of the same plant, the greater part of which are filled with brown colouring matter. They chiefly occur in bundles lying parallel with the woody fibres and vessels, and the outer tubes in each bundle give off numerous branches, which frequently anastomose and form a network, as shown in Plate IV. fig. 31. Many of the tubes are empty, but still their membranous walls are well shown.

P 4. A vertical section of the stem of *Sonchus palustris*, exhibiting a large number of laticiferous vessels, the greater part of which are filled with dark granular matter; many occur in bundles, and are the largest vessels, whilst others, of smaller size, form a network between the bundles. At one extremity of the preparation, as well as in the middle where it has been torn, may be seen small globules and masses of the latex which have escaped from the vessels.

P 5. A vertical section of the stem of an Euphorbia, *Euphorbia Brignii*, exhibiting laticiferous vessels, which run chiefly in the same direction as the woody fibres, but are readily distinguished from them by their granular contents.

P 6. A vertical section of the stem of an Euphorbia, *Euphorbia splendens*, which exhibits laticiferous vessels of large size running in various directions amongst the cellular tissue; some of them are empty, others full of granular matter, with which may occasionally be noticed a few of the

club-shaped bodies before described, under the head of starch, in Preparation E 14, and represented in Plate IV. fig. 6.

P 7. A vertical section of the stem of the same Euphorbia, in which the laticiferous vessels occur in greater abundance than in the preceding specimen; some are isolated, so that the nature of their walls and the giving off of their branches can be more plainly examined.

P 8. Laticiferous vessels obtained from the root of the Dandelion, *Leontodon taraxacum*; they occur in bundles and are full of brown granular matter, which has separated into short lengths; the continuity of the vessel however is not destroyed, but can be traced from one brown mass to another. These vessels are of smaller size than those of any of the preceding specimens.

P 9. Laticiferous vessels obtained from a species of Euphorbia; they are of large size and take a parallel direction like the woody fibres, from which they are not easily to be distinguished when their brown colouring matter is absent; in some cases the vessels are full of latex, in others the latex is contracted into a small cylindrical mass which occupies the centre of the vessels. In this preparation other vessels of small size and irregular shapes, but frequently anastomosing, cross the larger ones at various angles, so that it would appear there are two forms of laticiferous tissue in this plant.

P 10. A similar preparation, in which the woody fibres are more abundant, and can therefore be more easily distinguished from the laticiferous vessels; the fibres are known by their uniformity of size and by having pointed extremities; some specimens have the walls longitudinally striated, whilst others are minutely granular, or may even be said to contain granular matter in their interior. The vessels, on the contrary, are irregular in size and continually cross the fibres at different angles; they mostly contain brown colouring matter, which does not entirely fill their cavity but is contracted into small irregular masses in their centre, on the outside of which the membranous wall is visible. In many parts of the preparation the latex that has escaped from the vessels is collected

into large irregular nodules, which may readily be distinguished by their brown colour.

Series IX.

Hard Tissue.

Although all the specimens which will be included under this head belong strictly to one or other of the series already described, yet as they resemble, to a certain extent, the bony tissues of animals, it has been thought proper to classify them under the name of hard tissue, as a corresponding series will be included in the Histology of Animals.

The hard tissue consists of cells of various shapes and sizes, whose walls have become thickened by an internal deposit of secondary matter, termed *Sclerogen* by Turpin; this, as before stated, may take place in a homogeneous form or in concentric strata, so as either to fill up the whole interior of the cell, or certain radiating canals or pores may be left in the deposit, all of which communicate directly with the central cavity of the cell; but although they frequently branch, yet they never communicate like bone-corpuscles with the canals of adjoining cells, the cell-wall being always present and forming a line of separation between them.

The most striking examples of this tissue occur in the stones and outer coverings of fruits and seeds; these in some cases are so soft as to be cut with a knife sufficiently thin for examination by the microscope, or the individual cells may be separated from each other by maceration; whilst in others the aid of grinding and polishing, as in the case of bones and teeth, will be necessary before their structure can be satisfactorily determined. However hard the *sclerogen* may become, either by age or change in chemical composition, it nevertheless was originally soft, its deposition having commenced as soon as the cell had arrived at a state of maturity.

a. *Hard tissue with cells in an isolated condition.*

Q 1. A portion of the edible part of a Pear, exhibiting numerous elongated pulpy cells, among which may be seen others small and very dense; these are aggregated together in the shape of a star somewhat resembling the conglomerate form of raphides. Each cell is thickened by a deposit

of sclerogen, and a minute cavity with branching canals, like those in the lacunæ of bone, occupies the centre. These thickened cells form a good example of that species of hard tissue which has received the name of *gritty*, on account of the peculiar sensation felt either in cutting through it by the knife, or when it is brought between the teeth.

Q 2. A series of cells obtained by maceration from the central portion of a Pear; many are very delicate and of an elongated oval figure, but those requiring especial mention here are broader and more angular and of stony hardness; their cavity is in great measure filled up with sclerogen, a small spot in the centre with a few branching canals being the only parts unoccupied by the deposit. In their natural situation these thickened cells are arranged in stellate form, but in this preparation they are more or less detached, and their structure, as represented in Plate I. fig. 3 *d*, more plainly exhibited.

b. *Hard tissue with cells in juxtaposition.*

Q 3. A transverse section of Snake-wood, *Brosimum guianensis*, which is remarkable for the thickness of the walls of the woody fibres; amongst them however may be seen cells of large size, Plate I. fig. 3 *a*, the cavities of which are nearly filled with concentric laminæ of hard matter, leaving only a small chamber with but few lateral branches. The medullary rays are present, consisting each of a row of oval cells, most of which are occupied by a rhombohedral crystal.

Q 4. A similar preparation of Snake-wood, exhibiting numerous thick-walled cells of woody tissue transversely divided, amongst which are situated larger oval cells with secondary matter deposited in concentric laminæ; on either side of these are oval cells of intermediate size, arranged in linear series, many of which contain a rhombohedral crystal.

Q 5. A vertical section of the same Snake-wood, exhibiting bundles of woody fibres of brown colour, crossed at right angles by the medullary rays of still browner hue; in a line with them are the oval cells containing the raphides and others with cavities like bone-cells. The large cells with concentric laminæ are seen disposed in a linear series, and also

display very plainly the arrangement of the layers of deposit in their interior.

Q 6. A similar preparation, in which the large thick-walled cells are more numerous than in the last specimen; those woody fibres and cells that have cavities in their centre unoccupied by deposit of sclerogen, contain resinous matter of a rich brown colour.

Q 7. A vertical section of the pericarp of *Malpighia lucida*, showing numerous thick-walled cells, divided both transversely and longitudinally; the former are of small size and more or less oval in shape, whilst the latter are in some cases as long as $\frac{1}{25}$ of an inch; they are also disposed in wavy lines, and their cavities, when filled with air, are seen to be tubular, with here and there a lateral canal; these last are mingled without much order amongst the smaller cells. *Presented by P. B. Ayres, M.D.*

Q 8. A portion of the testa of the seed of *Acanthodium spicatum*, which appears to consist of a series of small wavy cells with thick and transparent walls, having their cavities occupied with sclerogen of dark-brown colour, as shown in Plate IV. fig. 24; amongst these are seen a few large oval cells, not unlike stomata in shape; they are arranged with some regularity near that edge of the specimen, which is straight and of a brown hue. *Presented by R. Kippist, Esq.*

Q 9. A portion apparently of the testa of the seed of the Tamarind, *Tamarindus indica*, composed entirely of elongated cells arranged in a wavy manner. The cells are solid, with the exception of small pores in their walls and a central cavity proportionably minute. The pores resemble so many transverse striæ. A confervoid growth may be noticed upon some parts of the upper surface of the specimen.

Q 10. A similar preparation dried and mounted in Canada balsam. This specimen consists of two or more layers of thickened cells, some of which are very broad and provided with a central cavity, like that in the cocoa-nut and other hard vegetable tissues. The cavities are in some cases filled with air, by which their true shape is rendered more evident.

Q 11. A vertical section of the seed of *Melia Azederach*, which consists of a

layer of parallel wavy cells of great length, and so much thickened by deposit as to leave but a very small central cavity, with which however numerous lateral branches communicate. This preparation greatly resembles the preceding. *Presented by P. B. Ayres, M.D.*

Q 12. A vertical section of a seed-vessel of *Carthamus tinctorius*, which is composed of an aggregation of elongated and sinuous cells; those on the margin have their cavities for the most part filled with Canada balsam, but notwithstanding, some few exhibit the shape of the cavities, which have numerous lateral branches. In the central opake part of the preparation may be noticed an immense number of small cells having cavities like bone-cells, and amongst them other cells full of bright crimson colouring-matter; these last are arranged in bundles which take an undulating course. *Presented by P. B. Ayres, M.D.*

Q 13. A vertical section of an Euphorbiaceous Nut, consisting of numerous thick-walled oval cells, varying considerably in size; each has a circular cavity with a few lateral branches or pores communicating with it. The new deposit in this specimen is remarkable, being of bright crimson colour, and exhibiting at the same time very plainly the concentric layers, which show the successive stages of deposition.
Presented by P. B. Ayres, M.D.

Q 14. A vertical section of the testa of the seed of *Vitex leucoxylon*, which is composed of thick-walled cells, closely aggregated together, with cavities much resembling bone-cells. *Presented by P. B. Ayres, M.D.*

Q 15. A vertical section of the testa of *Pinus pinea*, consisting of thick-walled cells with radiating cavities; remarkable for being filled with rich brown colouring-matter. *Presented by P. B. Ayres, M.D.*

Q 16. A vertical section of the shell of a Palm, consisting of a series of more or less elongated cells arranged in a wavy manner; the cavities of the cells have numerous lateral branches.
Presented by P. B. Ayres, M.D.

Q 17. A vertical section of the stone of an Apricot, exhibiting a close arrange-

ment of more or less oval cells, remarkable for the regularity and beauty of their cavities and lateral branches.

Q 18. A vertical section of the stone of the Apricot, which consists of cells of nearly uniform size; they are hexagonal in figure, and their central cavities large and provided with numerous lateral canals. Many of the cavities are filled with Canada balsam, others with air; the latter show the form of the cavity best, whilst the former appear as though there were two cells, one within the other.

Q 19. A transverse section of the Nut known as the Vegetable Ivory, *Phytelephas macrocarpa*; it is composed of an aggregation of cells, more or less thickened by deposit of sclerogen. A circular cavity still remains from which canals radiate as far as the wall of the cell, at which point each canal terminates in a slightly dilated extremity, but in no case do they anastomose with the canals of adjoining cells. Plate III. fig. 7 *b*.

Q 20. A longitudinal section of the same Nut, exhibiting the cells divided vertically. They are about $\frac{1}{100}$ of an inch in length, and the canals at their extremities much larger and more extensively branched than those given off from the sides. Plate III. fig. 7 *a*.

Q 21. A section of the same Nut, half of which is cut longitudinally and the remainder more or less obliquely. In the former half the cells are narrow and of great length; in the latter they are much shorter, and the cavities very broad. In all the cells the canals are most numerous at the extremities, and very few of them exhibit any trace of cell-wall.

Q 22. A vertical section of another Nut, which has been charred and afterwards mounted in Canada balsam. It exhibits the walls of the cells more plainly than the preceding preparations, but not the pores in them.

Q 23. A transverse section of the same Ivory Nut as that from which the preceding specimen was taken, and like it first charred and afterwards mounted in Canada balsam; it exhibits very plainly the line of demarcation between the cells, even more so than the specimens mounted in fluid.

Q 24. A vertical section of the outer brown husk or shell of the Ivory Nut, which consists of a series of dark-coloured cells, remarkable for the beautiful arrangement of the pores around the central cavity; in some parts of the specimen the cells are divided vertically, in others more or less horizontally; in the latter case they are seen to be of hexagonal form with a small central cavity and numerous radii or pores proceeding from it to the cell-wall; there is no branching of the pores as frequently seen in other specimens of hard tissue.

Q 25. A transverse section of the husk of the same Nut, in which the cells are chiefly divided across their short diameters; the walls of the cells are of hexagonal figure, the central cavity small, and pores, which are very numerous, proceed as so many radii from the centre to the wall of the cell. A portion of this preparation is represented in Plate III. fig. 10 *b*. All the cells are remarkable for their brown colour.

Q 26. A transverse section of the seed of the Star Anise, *Illicium anisatum*, which consists of a series of cells remarkable for the large size of their central and radiating cavities; these very much resemble bone-cells. The radiating cavities or pores have smaller pores given off from them nearly at right angles. The deposit in the interior of the cells is arranged in concentric strata, but from the spherical form of the cell this is not always plainly seen. A portion of this specimen is represented in Plate III. fig. 11 *a*.

Q 27. A vertical section of the same seed, in which the cells are of rich brown tint; their cavities are larger than those of the preceding specimen, and only portions of them can be seen in focus at the same time. When the upper portion of the seed is in focus the branching pores are alone visible; as the adjustment is moved the central cavities come into view, and with them the larger radiating pores; another slight adjustment will display the concentric layers of the secondary deposit, which is of rich yellow colour.

Q 28. A vertical section of the shell of a Cocoa-nut, *Cocos nucifera*, exhibiting thickened cells of various sizes; some are oval with large cavities and numerous canals radiating from them, whilst others are of great length

and have cavities proportionately large, resembling very much the bone-cells in some of the lower Reptilia. The cell-walls in all are very distinct.

Q 29. A vertical section of the shell of the same Cocoa-nut, in which is exhibited the effect of making the section very thin. The cell-walls are plainly shown, but the cavities of the cells are mostly rendered transparent by the Canada balsam; they all however are of light brown colour, and the contents of the cavities of much richer tint.

Q 30. A transverse section of the shell of the seed of the Croton Oil-plant, *Croton tiglium*, which is composed of a series of small cells of more or less oval figure; these are nearly full of secondary deposit of sclerogen, with a small cavity in the centre from which numerous very minute markings radiate towards the circumference, and are so delicate as to require a power of at least 200 diameters to define them; in other parts of the section the cells are divided longitudinally; in them scarcely any trace of more than the large central aperture of the cell can be seen. Plate III. fig. 10 *a*. *Presented by P. B. Ayres, M.D.*

Q 31. A transverse section of the siliceous epidermis of *Coix lachryma*, which exhibits three or more laminæ of cells; these are cut in various directions, some transversely, when the cells are seen of circular figure with a cavity provided with lateral branches; from this variety every transition may be noticed up to cells divided in the direction of their length; these exhibit narrow elongated cavities with numerous short lateral branches. *Presented by P. B. Ayres, M.D.*

Q 32. A vertical section of the seed of *Gmeline parviflora*, which consists of an aggregation of small oval cells, having cavities in their interior like bone-cells. In the thicker parts of the preparation the cavities are so numerous as to obscure the cell-walls.

Presented by P. B. Ayres, M.D.

Q 33. A vertical section of the seed of *Grewia oppositifolia*, which exhibits scarcely any trace of cell-walls, but at the same time the cavities of the

cells are very abundant, they appear scattered about in various directions, and are like the cells in the bones of some species of fishes.

Presented by P. B. Ayres, M.D.

Q 34. Two small vertical sections of the shell of a Palm Nut, which exhibit cells of various shapes, each having a cavity with numerous lateral branches; some of these are filled with bright yellow colouring-matter.

Presented by P. B. Ayres, M.D.

Q 35. A vertical section of the shell of an Almond, *Amygdalus dulcis*, which consists of a series of more or less elongated cells with very distinct walls, arranged in various directions; those which have their cavities occupied by air present a very peculiar appearance; the central portion can only occasionally be seen on account of the vast number of lateral branches given off in a spiral direction, so that if those cells in which the central cavity is well shown be carefully examined, a double spiral arrangement of the lateral pores or branches is very evident.

Q 36. A vertical section of the shell of a Hazel Nut, *Corylus avellanus*, in which are shown large thickened cells, divided both transversely and vertically; the former occur chiefly at that end of the specimen nearest the number, and exhibit a distinct cell-wall of which the shape is more or less oval; the middle of the cell has a cavity of large size with radiating canaliculi like a bone-cell, the latter or vertically divided cells are much elongated and lie in parallel rows, their cavities being very similar to the bone-cells in Reptiles; in other parts of the preparation the cells present cavities of various shapes according to the direction in which the section of them has been made. Plate III. fig. 11 *b*. *Presented by P. B. Ayres, M.D.*

Q 37. A vertical section of the shell of a Hazel Nut, *Corylus avellanus*, which consists of small hexagonal cells, with small central cavities but with radiating pores of large size; in many parts of the specimen the Canada balsam in which it has been mounted has entered the greater number of the pores, whence the others, not so filled and therefore not appearing to be connected with the central cavity, resemble small prismatic crystals. The edges of the preparation show only one layer of cells, but the

middle is so thick that only the pores in the superficial cells can be seen.

Q 38. A vertical section of the stone of a Plum, *Prunus domesticus*, which consists of a layer of more or less hexagonal cells, each presenting a central cavity and radiating pores of large size; these are best seen at the thickest edge of the specimen; at the thinnest edge the shape of the individual cells can be well seen, but their radiating system of canals is nearly occupied by the Canada balsam, and only a short line, like that of a prismatic crystal, remains visible in these parts.

Q 39. A vertical section of the stone of a Plum, *Prunus domesticus*, consisting of cells of different shapes and sizes, but all possessing central cavities resembling bone-cells; those that have been divided vertically exhibit both the longest and largest cavities, whilst others that have been divided transversely show the hexagonal outline of the cell and the pores radiating from the central cavity.

Q 40. A vertical section through the long diameter of the stone of a Plum, known as the Orleans variety; it exhibits thickened cells divided both vertically and horizontally in all parts except at the two extremities, in which the cells are elongated and exhibit corresponding lengthened cavities very much resembling those in the Tamarind; many of these latter cells are so much like those of the woody tubes of some plants that they form a very good connecting link between them and the ordinary cells of cellular tissue.

Q 41. A vertical section of the stone of a Plum, of the variety known as the Golden Drop; it consists of one side of the stone only, and exhibits three kinds of cells; two are either hexagonal or oblong in figure, whilst the third (which is best seen when the lower concave edge of the section is brought into view) presents a wavy bundle of the elongated form of cell previously described, which so much resembles the thickened tubes of wood.

Q 42. A vertical section of the stone of a Wild Cherry, *Cerasus avium*; it includes about one-half of the side of the stone only, but although of small

size its structure is nevertheless very remarkable; the cells are rather small and present a hexagonal appearance; their central cavities are of large size, and the radiating pores so numerous that all those filled with air appear as so many oval bodies covered with projecting spines, like those of the gemmules of certain species of sponge; on one edge there occurs a bundle of the elongated cells, which, like the shorter specimens, are surrounded by pores.

Q 43. A vertical section of the stone of a Peach, *Amygdalus*, made through its long diameter; it exhibits a central oval cavity in which the kernel was lodged, and smaller openings and furrows in its margins, some of which were occupied by spiral and other vessels. When examined with a power of 200 linear, the whole mass of the stone is seen to be composed of cells of various shapes and sizes, all of which are remarkable for the great development of their central cavities and the radiating pores communicating with them. The cells having their cavities filled with rich yellow colouring-matter are not so clearly seen as those containing air.

Q 44. A transverse section of a Coquilla Nut, which consists of a series of more or less hexagonal cells of yellow colour; they are entirely filled up with deposit of secondary matter, with the exception of a small oval cavity and some radiating canals; the latter are so few in number as to give the cavity, when filled with air, great resemblance to the bone-cells in the scale of the Lepidosteus. Many of the cavities are occupied by yellow colouring-matter, and in these cells no radiating canals are visible.

Q 45. A vertical section of the same Coquilla Nut, in which the cells are of more elongated figure; many of them have their cavities filled with yellow colouring-matter, others present radiating canals communicating with a central cavity resembling the bone-cell of some Reptilia. Large yellow spots may be observed in some parts of the preparation, around which the cells are of small size and very thickly arranged.

Q 46. A transverse section of the outer brown portion of the fruit of the Sago Palm, *Sagus Rumphii*, which consists of cells of very small size, arranged for the most part in parallel rows; they are of rich brown colour, and

nearly filled up with secondary deposit; in by far the greater number the central cavity is occupied by a darker brown substance, but the instances are rare in which radiating canals are present. These cells appear to lie upon others of larger size with thin transparent walls.

Q 47. A vertical section of the outer brown portion of the fruit of *Sagus Rumphii*, consisting of large thick-walled cells, many of which are filled with rich brown colouring-matter. On that part of the specimen forming the outer surface of the fruit, the cells are smallest, of brown colour, and nearly solid; proceeding towards the lower edge, the cells become more elongated, lose their colouring-matter, and exhibit numerous radiating canals and large central cavities, until at last they are so long as to resemble the cells of porous tissue or Bothrenchym.

Q 48. A portion of the investing membrane of the seed of *Sagus Rumphii*; it is of greyish colour, and consists of cells with large central cavities and very numerous canals radiating from them.

Q 49. A vertical section of the hard kernel or seed of *Sagus Rumphii*, consisting of thick-walled cells of large size, similar to those of the Ivory Nut, represented in Plate III. fig. 7 *a*, *b*. The central cavity is empty, but short pores communicating with it are seen in the transparent cell-walls, these terminate in dilated extremities, as in the Ivory Nut before alluded to; the pore in the wall of one cell being exactly opposite to that in the neighbouring one, but they never meet. In some parts of the specimen, a delicate marking, indicating the original walls of the cells, forms a line of separation between them.

HISTOLOGICAL CATALOGUE.

PHYSIOLOGICAL SERIES.

Division II.

HISTOLOGY OF ANIMALS.

ANIMALS, like vegetables in their earliest condition, consist of minute cells of a spheroidal or oval form, the walls of which are composed of a delicate transparent membrane; by the multiplication and growth of these cells various structures are formed, which have received the name of *Tissues*. In some cases, as in cartilage and fat, the tissues retain their cellular character throughout life; in others the cells undergo certain changes in form, and give rise to structures of a perfectly distinct character, such as membranes, fibres, tubes, &c.

The animal, like the vegetable cell in its embryonic state, is also provided with a nucleus or cytoblast, having occasionally a smaller cell or nucleolus within it. The nucleus is sometimes the centre or spot in which the transformation or growth of cells into tissues first takes place, but most frequently the cell-wall is engaged in this process; in many forms of tissue, as the areolar, and in muscle and nerve, the nucleus may still be recognised even after all trace of the cell-wall has entirely disappeared. However much the tissues of animals may resemble those of vegetables in many of their characters, they nevertheless differ from them in one essential particular, viz. in being more or less directly nourished by a nutritious fluid termed blood, which circulates in minute vessels in the immediate vicinity of the solid elements of the different tissues. In some tissues,

as in horn, feathers and cuticle, no vessels are found, even in their thickest parts; whilst bone, which is harder in structure than these, is everywhere permeated by blood-vessels; to the former three the term non-vascular or extra-vascular is applied, whilst the latter is called vascular. The proximity of the blood-vessels to the elements of any tissue is generally considered to be, to a certain extent, the measure of its vital functions.

For our knowledge of the development of animal tissues through cells, we are mainly indebted to the labours of Professor Schwann of Berlin, who has divided all the elementary forms of structure into different classes; according to him, the cells in some tissues are free and isolated, and exist either in fluids, or lie unconnected one from the other and moveable, as for instance the red and white corpuscles of the blood, and those of lymph and mucus. In others the cells are united into continuous tissues, as in cuticular appendages, viz. Hair, Nails, Feathers, &c. In others, as in cartilage, the cell-walls may be adherent, or the cells themselves may be united together by a substance termed from its situation *intercellular*; this in some cases is structureless, in others granular or even fibrous. In some instances the cell-wall is developed into a series of fibres, as in the areolar and elastic tissues, or both the cell-walls and their cavities may unite and form continuous tubes, as in muscle, nerve and capillary vessels.

This classification, although very convenient in many points, is nevertheless acknowledged by Schwann himself to be attended with some considerable difficulties in its practical application; but as it is necessary for the purposes of study that some kind of classification should be employed, that given by Messrs. Todd and Bowman in their Physiological Anatomy, being one of the best that has been drawn up, will be adopted in the present work, with some few alterations.

Tabular view of the Animal Tissues.

1. Simple membrane: employed alone or in the formation of compound membranes.	Examples:—Walls of cells. Posterior layer of the cornea. Capsule of lens. Sarcolemma of muscle, &c.
2. Fibrous tissues.	White and yellow fibrous tissue. Areolar tissue. Elastic tissue, &c.
3. Cellular tissues.	Cartilage. Fat. Pigment. Grey nervous matter, &c.
4. Sclerous or hard tissues.	Rudimentary skeleton of Invertebrata. Bone. Teeth, &c.

5. Compound membranes: composed of simple membrane, and a layer of cells, of various forms (epithelium or epidermis), or of areolar tissue and epithelium.	Mucous membrane. Skin. True or secreting glands. Serous and synovial membranes.
6. Compound tissues: *a*, composed of tubes of homogeneous membrane, containing a peculiar substance.	Muscle. Nerve.
b. Composed of white fibrous tissues and cartilage.	Fibro-cartilage.

The growth and transformation of cells will be treated of in that part of the Catalogue devoted to the development of vegetable and animal tissues: the series of preparations to be described in this volume, will, with few exceptions, be such as exhibit normal structure only.

Series I.

Simple Membrane.

When viewed with the highest magnifying powers, simple membrane in the majority of instances is found to be of great transparency and perfectly structureless; its principal use in the animal economy is that of performing the office of a tegumentary or investing tissue, and as such it is employed in the walls of cells, as of the blood, lymph, fat, &c., and as a sheath to the fibres of muscle and nerve. In all these cases the membrane is perfectly structureless, but in many of the cystic entozoa termed hydatids, the membrane, although to all appearances perfectly transparent and structureless, is nevertheless occasionally found to be minutely granular.

Like vegetable membrane, it does not present any visible pores, although fluids readily pass through it; wherever it exists it is more or less nourished by blood-vessels, which run on its outer surface, but never perforate it.

a. *Extended membrane.*

A a 1. A portion of the posterior half of the capsule of the lens of the eye of a Sheep, which is composed entirely of structureless membrane, and however highly magnified, exhibits no trace of structure.

A a 2. A portion of the posterior half of the capsule of the lens of the eye of

the Human subject, which, like the preceding specimen, consists entirely of structureless membrane.

A a 3. A portion of the posterior layer of the cornea of the eye of a Sheep, which is of extreme transparency, but still without any trace of granular or other structure.

A a 4. A portion of the posterior half of the capsule of the lens of the eye of a Kitten, the vessels of which are injected with size and vermilion. The membrane exhibits no trace of structure, but serves as a support to the vessels which are ramifying towards the iris. Plate V. fig. 3.

A a 5. A portion of the posterior half of the capsule of the lens of the eye of a Frog, *Rana temporaria*, with its vessels injected. The membrane is perfectly structureless, and the vessels are of much greater size than those of the preceding specimen.

b. *Membrane in the form of a sheath.*

A a 6. Fasciculi of muscle of an Eel, *Anguilla acutirostris*, which exhibit in those parts where the transverse striæ have been disturbed a delicate membrane termed sarcolemma, Plate V. fig. 2 *a*, *b*; it invests each fasciculus, but under the highest powers shows no trace of structure.

A a 7. A portion of the muscular substance of a Pigeon, the vessels of which are injected; these run in parallel lines between the fasciculi, but never penetrate the sarcolemma.

A a 8. A portion of a nerve of a Frog, consisting of a series of tubes or fibres, each one of which is invested with a sheath termed neurilemma: this, like the corresponding part in muscle, presents no trace of structure.

A a 9. A portion of a nerve of an Eel, *Anguilla acutirostris*, composed of an aggregation of tubes, which like the preceding are enveloped by neurilemma of extreme transparency, and perfectly structureless.

c. *Membrane in the form of cells.*

A a 10. Corpuscles of the blood of *Lepidosiren annectens*, which are of an oval figure $\frac{1}{570}$th in the long, by $\frac{1}{940}$th of an inch in the short diameter; they

consist of an outer wall of structureless membrane enclosing an oval nucleus, as shown in Plate V. fig. 2 *c*. With the single exception of the *Siren. lacertina*, these corpuscles are the largest that have yet been met with in any member of the animal kingdom. *Presented by Mr. C. M. Topping.*

A a 11. A transverse section of the chorda dorsalis of the Lamprey, *Petromyzon marinus*, consisting of cells with walls of structureless membrane; in many of them may be seen a small granular nucleus: this, as shown at *d d* in Plate V. fig. 1, is generally situated close to the cell-wall.

A a 12. A small portion of fat from the Human subject, consisting of a series of cells, with walls of structureless membrane. Plate V. fig. 1 *a*, *b*.

A a 13. A similar preparation of fat, the cells of which are arranged in the form of lobules; the blood-vessels distributed to the lobules are injected, they run between and around the cells, but never penetrate their walls.

A a 14. A portion of the ear of a Bat, which is composed of a series of more or less hexagonal, nucleated cells of cartilage; their walls, although flattened into scales, present no trace of granular or other structure.

Series II.

Fibrous Tissues.

Anatomists divide the fibrous tissues into two classes, the *white* and the *yellow*. The first is inelastic and of great strength; it presents to the eye a shining silvery white aspect, and appears to consist of bundles of very delicate fibres arranged in parallel wavy lines; in some cases the individual fibres may be readily separated from each other, in others they are so closely connected together as to form a continuous membrane; by the action of acetic acid the fibres swell up and lose all trace of their original structure, and at the same time disclose the presence of nuclei. The second is always more or less yellow in colour, and is composed of bundles of larger fibres, which are highly elastic; they often bifurcate and freely anastomose with each other, and their broken ends possess the curious property of curling up; both kinds are extensively used in the formation of membranes and ligaments, and in a state of combination form what is

now known as the *areolar tissue*, to which the term *cellular* was formerly applied by the old anatomists, in consequence of the fibres crossing each other at certain more or less regular distances, and forming between them spaces or areolæ; as these spaces however are not true cells, but communicate one with the other, the name of *areolar* has been given, and that of *cellular* is now restricted to such tissues as cartilage and fat in which true closed cells always exist.

Subseries I. *White Fibrous Tissue.*

A b 1. A portion of the tendon of the rectus externus muscle of the eye of a Human subject; it appears to consist of delicate parallel wavy fibres, which when viewed by reflected light present a silvery appearance; the individual fibres can only occasionally be separated from each other, and they vary so much in size that it would be difficult to give to any one the name of an ultimate fibre. The curly fibres seen near the edges of the specimen belong to the areolar tissue which invested the tendon in the form of a sheath. Plate V. fig. 4.

A b 2. A portion of the cordiform tendon of the diaphragm of a Rat, which exhibits the white fibrous tissue to very great advantage; in consequence of the fibres being invested on both sides by a serous membrane, little or no areolar tissue is present.

A b 3. A portion of periosteum removed from the middle of the shaft of the right humerus of a human fœtus of full time; it consists of strong parallel fibres having a silvery aspect; other fibres, running more or less obliquely, are closely connected with them; these belong to a tendon, and show how intimately the fibres of the latter are blended with those of the periosteum.

A b 4. A portion of a thin tendon from the eye of a Sheep; it has been acted on by acetic acid, and nearly all trace of fibrous structure has disappeared; the fibres are swollen up, and numerous small oval nuclei are now rendered visible; some few large fibres may occasionally be observed: these consist of the yellow fibrous element of the areolar tissue which invested the tendon, and unlike the white fibres are not acted on by the acid.

a. *Vessels of white fibrous tissue.*

The vessels of white fibrous tissue are few in number, and run for the most part parallel with the bundles of the fibres; in tendons occasionally two sets of vessels are present, the one forming a rich network on the outer surface, the other consisting of a few parallel vessels which run between the bundles of fibres. Other forms of fibrous tissue, as the periosteum and dura mater, are largely supplied with vessels, their office being to nourish the bones with which they are in immediate contact.

A b 5. A portion of a muscle of a Kitten with its tendon attached; the vessels of both are injected, and the tendon can be easily recognised by its small amount of vascularity; the vessels are arranged in one plane, and run in parallel lines, having transverse branches communicating with them at nearly equal distances.

A b 6. A portion of a large tendon from the leg of an Ostrich, which has been divided vertically in such a manner as to exhibit the vessels running in parallel lines between the fasciculi of fibres; they are of large size, and have oblique connecting branches at certain regular intervals, as shown at *a* in Plate V. fig. 5.

A b 7. A similar preparation, in which two sets of vessels may be seen; the one in the interior of the tendon, which resembles that of the preceding specimen; whilst the other, occurring on the outer surface, consists of larger vessels, which repeatedly branch and form rich capillary plexuses; these in many cases are surrounded by other vessels of considerable size in the form of a square or parallelogram; these capillaries are most probably employed in secreting a fluid to lubricate the opposed surfaces of two tendons, and are not therefore engaged in nourishing the tendon itself.

A b 8. A portion of periosteum removed from the Tibia of a human fœtus; it exhibits a parallel arrangement of vessels not unlike those of muscle or tendon, but on a much coarser scale; some of the vessels have truncated extremities, which arise from their having given off branches to the canals of the bone which has been removed from the periosteum. Plate XIII. fig. 11.

A b 9. A portion of periosteum removed from the Tibia of a fœtal Calf; the finer

network of vessels belongs to some attached portions of muscle, whilst the coarser parallel arrangement belongs to the periosteum; at the end nearest the name there will be seen some small pieces of bone; this part of the preparation belonged to the head of the Tibia just below the epiphysis.

Subseries II. *Yellow Fibrous Tissue.*

A c 1. A portion of the ligamentum nuchæ from the neck of a Sheep, which consists of large yellow branching fibres, the broken ends of which have the peculiar property of curling back upon themselves; in some parts of the preparation the fibres are closely connected together, in others short pieces have been detached, which give the average diameter of an individual fibre as being about $\frac{1}{4000}$th of an inch*. Plate V. fig. 9.

A c 2. A portion of the ligamentum nuchæ from the neck of an Ox, which presents the same peculiarities as the preceding specimen, but the fibres are rather larger in size.

A c 3. A portion of the same ligament from the neck of the Elephant, in which the fibres are of very much larger size than in any of the preceding specimens, but like them all the broken ends have the property of curling up; they are rarely if ever pointed, but are fractured more or less transversely. Many fibres in this specimen are larger than $\frac{1}{3000}$th of an inch; some of these may be seen to give off two or more small branches, each having a curly extremity.

A c 4. A portion of a large band of elastic tissue, taken from the wall of the abdomen of the same Elephant, over the muscles of which cavity it was spread in the form of a dense fascia; the fibres present precisely the same characters as those of the preceding specimen.

A c 5. A portion of one of the ligamenta subflava of the Human subject, which extended between the arches of the first and second lumbar vertebræ; it

* The fibres are so intimately blended with each other, that great difficulty is often experienced in separating them, and they will frequently break before the separation can be effected, which will account for all the detached pieces which occur in some parts of the preparation.

is composed of a thick layer of yellow elastic fibres, which by frequently bifurcating and anastomosing with each other, produce a series of reticulations. The fibres themselves vary considerably in size, and their average diameter is much less than those of the sheep or ox.

A c 6. A portion of the ligamentum nuchæ from the neck of the Giraffe; which consists of yellow elastic fibres, of larger size than those of the Elephant. The ends possess the peculiar property of curling up, but the fibres themselves differ from any other form of elastic tissue yet described, in having transverse markings, which occur at nearly regular distances, and appear to be produced by the puckering up of an internal membrane, whereby minute cells or spaces are formed, like those occurring in the hairs of some of the smaller mammalia. A few fibres are represented at *a* in Plate V. fig. 10, as seen under a power of two hundred diameters; portions of other fibres, magnified four hundred diameters, are represented by *b*, *c*, *d*; in these the nature of the markings is more clearly shown.

A c 7. A portion of the same ligament, in which the individual fibres have been more carefully detached from each other, so that their intimate structure can be better seen.

The ligament, from which these specimens were taken, was upwards of eight pounds in weight, and six feet two inches in length; on separating it from its several attachments to the spinous processes of the vertebræ, it immediately contracted to four feet. With the exception of a strong sheath of areolar tissue, which passed into its interior, and separated some of the bundles of fibres, the entire ligament was composed of yellow elastic tissue. When the peculiar transverse striæ were first seen, the ligament was in one piece; since then, it has been divided transversely in many places, and it has been found that the fibres from the centre, although more dense than those from the outer surface, and in the majority of cases much larger in size, do not present the transverse markings; in them, however, a linear stripe may occasionally be seen, which affords an indication of a tubular character.

A c 8. A portion of the centre of the same ligament, in which the fibres are of very large size, but without any trace of transverse striæ; many of them, on the contrary, exhibit a linear marking in the centre.

a. *Vessels of Yellow Fibrous Tissue.*

A c 9. A portion of the ligamentum nuchæ from the neck of a Calf, the blood-vessels of which are injected; they are arranged principally in parallel lines, and have occasional anastomosing branches. They run in the areolar tissue between the bundles of fibres, and somewhat resemble in their mode of arrangement the vessels of muscle.

A c 10. A similar preparation, in which the blood-vessels have been more successfully filled; in some parts small wavy capillaries may be noticed; these belong to masses of fat which are situated in the areolar tissue. The vessels in a small portion of this specimen are represented in Plate V. fig. 12 *b*.

b. *Ligaments of Shells.*

A peculiar kind of elastic tissue occurs in the form of a ligament, between the valves of the shells of conchiferous Mollusks, and is situated either on the inner or the outer side of the hinge; the object of the ligament is purely mechanical, and it may be considered as an antagonist to the large adductor muscles, which are employed in closing the shell. In some bivalves, as the Cockle, the ligament is external to the hinge, whilst in the Mussel it is internal to it; that is, in the first case, the power is before the fulcrum, and in the second case behind it. When the former is examined microscopically, its structure appears horny and homogeneous; but the latter consists of two different kinds of tissue, one resembling the ligament on the inside of the hinge, and the other being composed of numerous fibres, about the $\frac{1}{5000}$th of an inch in diameter, which run parallel to each other, and appear to be crossed at right angles by other delicate fibres, but in very thin sections, traces of these last are rarely visible.

A d 1. A vertical section of the ligament of the Oyster (*Ostrea edulis*). It consists of two distinct structures, one perfectly homogeneous, the other fibrous; this last occurs in that part of the ligament situated on the outside of the hinge; the individual fibres vary from the $\frac{1}{4000}$th to $\frac{1}{7000}$th of an inch, but exhibit no trace whatever of transverse striæ, although the power of opening the valves, on account of its situation behind the fulcrum, must be contractile like that of muscle.

A d 2. A vertical section of the ligament of the hinge of *Tridachna hippopus*,

consisting of rows of fibres about $\frac{1}{5000}$th of an inch in diameter; each fibre appears to be of a cylindrical figure, and presents greenish markings at regular distances from each other; the coinciding of these markings, as the fibres lie side by side, gives rise to an appearance of transverse striæ. In certain lights, this preparation, on account of the closeness of its fibrous structure, is beautifully iridescent.

A d 3. Two vertical sections of the ligament of the hinge of *Cyrena purpurea*. They present even to the naked eye a fibrous structure, and exhibit striæ crossing the fibres transversely. When viewed with a power of 200 linear, the cylindrical fibres are plainly seen, as in the other specimens; but these are besides peculiarly remarkable for their iridescent appearance; a portion of this structure is represented in Plate V. fig. 12 *a*.

A d 4. A vertical section from the ligament of the shell of *Tridachna gigas*, 32 inches in length; this specimen, which has been long dry, and has lost all its elastic property, when examined microscopically, still exhibits its characteristic fibrous structure; the individual fibres are much larger than those from any of the other smaller shells; but still there is not so great a disparity between them, as the immense size of this species of shell would at first sight lead persons to imagine.

c. *Structure of Membrane of Egg Shell.*

A e 1. A portion of the animal matter of the shell of an Egg of the common Fowl, the carbonate of lime having been removed by dilute hydrochloric acid. It consists of several layers of fibres of nearly uniform diameter, which interlace with each other, and produce a series of spaces or cells: the diameter of the principal fibres is $\frac{1}{8000}$th of an inch.

A e 2. A portion of the membrana putaminis, or membrane lining the interior of the shell. It presents precisely the same character as the preceding specimen, and one of its edges is so thin, that a single layer of fibres and their mode of interlacing are well-exhibited. Plate V. fig. 11.

For our knowledge of this interesting structure, we are indebted to Dr. W. B. Carpenter, who regards it as analogous to the chorion in mammalia, and considers the purpose answered by the fibrous arrangement to be that of allowing gases to pass through, whilst fluids are effectually retained.

Series III.

Areolar Tissue.

This tissue is more extensively employed than any other in the construction of the animal body, and its continuity may be traced from one region to another without interruption ; its principal use appears to be that of connecting other tissues together, and at the same time allowing more or less motion between them. It occurs abundantly under the skin as well as under the mucous and serous membranes ; and in these situations, for the sake of distinction, it has received the name of sub-cutaneous, sub-mucous, and sub-serous cellular tissues. In the form of a sheath, it invests all the muscles and serves as a support to the numerous vessels and nerves running between them, to all of which, perfect freedom of movement is allowed.

When viewed with the naked eye, areolar tissue presents the appearance of being composed of very fine fibres of a white colour, connected together by a delicate film or web, in which no structure can be seen; the fibres cross each other in every possible direction, and certain spaces or areolæ are left between them. When examined microscopically, it is found to consist principally of unbranched wavy threads of extreme minuteness, rarely occurring singly, but mostly united into bundles, which intersect each other in every possible direction ; but the fibres of one bundle never anastomose with those of another, although the bundles themselves frequently do. This may be considered as the white inelastic element of the tissue, and like that before described, as occurring in tendons, the individual fibres can rarely, if ever, be separated from each other ; in some specimens the fibrous appearance of the bundles is even so minute, as to be scarcely visible except with the highest powers.

A second but less common element is also found in areolar tissue ; this is the yellow elastic tissue, which consists of long branched filaments with curly extremities ; these may readily be seen in any specimens by adding acetic acid, when the white fibres in a great measure disappear, and the yellow not being acted on are brought plainly into view. The acid also brings out a few rounded and oval corpuscles ; these are chiefly situated in the areolæ, others are some-

times seen in rows attached to the outer surface of the bundles, or even stretching some little distance along their interior; these last are usually considered to be the nuclei of the cells, from which the white fibrous element was originally developed, and are most numerous in certain tumours connected with the skin, that are undoubtedly of a fibrous nature.

The yellow element of the areolar tissue is very abundant in certain situations, as for instance, under the skin, and beneath some of the serous and mucous membranes; in other parts of the body it is so sparingly supplied, and so hidden by the white filaments, that it cannot be discovered without the aid of acetic acid. A peculiar form of areolar tissue occurs at the base of the brain, in which situation it forms the support of the principal blood-vessels; on adding acetic acid to a portion of this tissue, the bundles of white fibres swell up and assume a tubular appearance, whilst the yellow fibres surround the tube in the form of a ring or spiral, and constrict it at certain intervals, as shown in Plate V. fig. 8 *a*, *b*, *c*: other bundles, although assuming a tubular character, have the yellow fibres scattered irregularly over them, with some few nuclei amongst them. The spiral disposition of the elastic fibres was first pointed out by Henlé; they have since been described by Hassall, who considers the tubular portion to be a blood-vessel in the first stage of development, and the coil of yellow fibre as its rudimentary coat of elastic tissue.

The continuity of the spaces or areolæ which are formed in this tissue, by the crossing and re-crossing of its bundles and individual fibres, is well-exemplified in cases of Anasarca and Emphysema; in which diseases, the areolæ, however far removed from the seat of injury, are sometimes filled with air or fluid; hence the term cell, formerly applied to these spaces, was obviously inappropriate.

A f 1. A portion of areolar tissue taken from underneath the skin of the Arm. At first sight it appears to consist of delicate white fibres only; these occur chiefly in bundles, some few of them are occasionally detached, and are very curly; the yellow elastic fibres are few in number, and can only be seen in one or two parts of the specimen; they may be known by their large size and distinctness of outline. Plate V. fig. 7 *a*, *b*.

A f 2. A portion of areolar tissue removed from the neighbourhood of the sheath of a tendon from the back of the Hand; a portion of tendon is still

present, and exhibits parallel wavy fibres running in one direction; the areolar tissue is best seen at the edges of the tendon, and is composed of delicate fibres which cross those of the tendon at different angles; the yellow element is represented by a few curly fibres of larger size than the white.

A f 3. A portion of areolar tissue removed from between the muscles of the wall of the abdomen of an Elephant; the white fibrous element is most abundant, and its individual fibres are rather larger than those in the human subject. The yellow element on the contrary is only occasionally to be seen; its fibres are of larger size, and have curly extremities.

A f 4. A portion of a subcutaneous tumour of the fibrous kind, removed from the back; it is composed entirely of white and yellow fibres, amongst which a few nuclei may occasionally be seen; the yellow fibres are very abundant in some parts, and give great toughness to the specimen.

A f 5. A portion of the same tumour, after having been acted on by weak acetic acid; the white fibrous structure is only faintly visible, but the yellow is brought out in strong relief; numerous cells and detached nuclei occur between the bundles and yellow fibres; some of the former are spindle-shaped, as shown in Plate V. fig. 8 *d*; others are so much elongated as to assume a fibrous character. Plate V. fig. 7 *c*, *d*, *e*.

A f 6. A portion of areolar tissue removed from the under surface of the mucous membrane of the human colon; when acted on by acetic acid, it exhibits numerous filaments of yellow fibrous tissue, amongst which may be seen several oval nucleated cells, some few of them even becoming elongated and fibrous.

A f 7. A portion of areolar tissue removed from around the vessels at the base of the brain of a Sheep; it chiefly consists of bundles of white fibrous tissue, interlacing each other in various directions, with yellow fibres scattered irregularly amongst them; small blood-vessels containing corpuscles may be seen in some parts of the preparation, and near to them are other delicate fibrous bands having the appearance of nerves.

A f 8. A portion of areolar tissue of the brain of a Sheep, removed from the vessels in the neighbourhood of the circle of Willis; the bands of white fibres, and the vessels were at first quite as apparent in this as in the preceding preparation; it has however been acted on by acetic acid, and the bundles of white fibres have taken on a tubular appearance, and the yellow fibres may be seen encircling them, as shown in Plate V. fig. 8*a*,*b*,*c*.

a. *Vessels of Areolar Tissue.*

Numerous blood-vessels of various sizes are met with in areolar tissue, the larger being destined to supply vascular organs in the immediate neighbourhood, whilst the smaller break up into capillaries to supply the tissue itself, and the fat vesicles which are contained within the areolæ; the same may be said of the nerves. The general arrangement of the larger vessels is in threes, an artery being situated between two veins; these cross each other, and map out certain more or less angular spaces, which in some measure resemble the shape of the areolæ.

A f 9. A portion of areolar tissue removed from between the muscles of the neck of a Pig about three weeks old, which was injected by the double injection, viz., acetate of lead and chromate of potash; entangled within the meshes of the tissue are several small masses of fat, some of which have had the fatty matter extracted by turpentine, whilst in others it is still present; the general arrangement of the vessels is, that an artery, surrounded or accompanied by a vein on each side, or an artery with a single vein, runs to all parts of the tissue, branches being given off at angles of 45°, and less; so that the capillary system, which obeys the same law as the larger branches, is arranged in a somewhat quadrilateral form, the spaces inclosed by the capillaries being of this figure. Traces of large nerves accompanying some of the vessels are likewise visible; although nothing remains of them but the neurilemma and its capillaries, the arrangement of which however is so characteristic as to afford a sufficient indication of their presence. If the largest vessels in this preparation be examined, on either side will be seen some very minute vessels running parallel to them, with a still smaller set between them; these are the nerves, and are readily to be recognised as such by the practised eye, the arrangement being something like that of voluntary muscle.

A portion of this preparation is represented in Plate V. fig. 6, and in the preparation itself the spot exhibiting the nerve fibres is surrounded by a black line.

A f 10. A preparation of a similar nature to the one last described; the vessels distributed to the fat cells are better shown, the fatty matter having been dissolved out by the turpentine; but the vessels of the areolar tissue itself are not very successfully exhibited.

A f 11. A similar preparation to the one last described; the vessels of the fat cells are very conspicuous in some parts, whilst in others the distribution of the three parallel vessels to the areolæ is seen; but the injection is not so successful as in Preparation A f 9.

When viewed as transparent objects with a power of 200 linear, the three preceding specimens all show corpuscles of blood in the larger vessels, and when the nerves in A f 9 are examined by the same power, their fibrous character is still to be seen.

A f 12. A portion of areolar tissue removed from the surface of one of a series of cartilaginous tumours of the joints of the Hand, called by Müller *Enchondroma*, and now forming Preparation No. 775 of the Pathological series; in many parts of the specimen the parallel arteries and veins are seen, whilst in others there is a rich net-work of vessels of areolar tissue, like those found in the neighbourhood of joints, from whence this preparation was taken.

A f 13. A portion of areolar tissue removed from the back of an extensor tendon of the human Hand. Two yellow lines will be seen where portions of the tendinous matter are left, and here the vessels are arranged in nearly parallel lines, over which some of those of muscle and areolar tissue are distributed; on either side of these tendinous lines are vessels of fat, and the fat cells may be seen forming a delicate hexagonal net-work, the oily matter having been dissolved out of them by turpentine.

A f 14. A portion of areolar tissue taken from between the muscles of the back of a fœtal Calf of nearly full time; it exhibits the characteristic arrangement of the larger blood-vessels and capillaries, viz., an artery accom-

panied by two veins, one on either side ; the former generally of smaller size than the latter ; in the capillary portion of the net-work, the three vessels are of uniform diameter.

Series IV.

Cellular Tissues.

Cartilage.

Cartilage is a highly elastic and flexible substance, largely used on account of these two valuable properties, in various parts of the vertebrate skeleton. In colour it is white or greyish white, inclining sometimes to yellow. In some animals it forms the entire skeleton, as in the Skates and Lampreys, which on this account are termed cartilaginous fishes ; but in the higher vertebrata it is only employed in part to form the skeleton in the adult animal. In the embryonic state of existence it is the first tissue that is fully developed, and with the growth of the animal is either wholly or partially converted into bone, the cartilage forming the nidus in which the ossific particles are first deposited.

Anatomists are in the habit of dividing this tissue into two kinds, the permanent and the temporary ; the first, or permanent kind, is employed either in the form of a membrane or tube to enclose cavities, when it is called *membraniform* ; or as a coating upon the ends of bones entering into the formation of joints, whence it has been termed *articular* ; the second, or temporary, includes the cartilage of the embryo above mentioned, as well as all other kinds, which in process of growth are transformed into bone. A peculiar kind of tissue is found in some species of morbid growths or tumours, which have been named by Müller *Enchondroma* ; these, as will hereafter be shown, resemble cartilage in most of its characters.

All the varieties of membraniform cartilage are invested by a layer of white fibrous tissue termed *perichondrium* ; this tissue, which is analogous to the periosteum of bone, serves as a support to the nutrient blood-vessels. The articular cartilages have no perichondrium ; but their immediate connection with a vascular synovial membrane and bone is sufficient to supply all the nutriment they may require.

The vessels of cartilage are few in number; the thinnest kinds are nourished by those in the perichondrium, the thicker are provided with canals, into which the perichondrium and vessels are transmitted; this is also the case with articular cartilages in their earliest stages of development, but in the adult state no vessel ever enters this tissue when in a healthy condition.

When examined microscopically, the *simplest* form of cartilage is found to resemble in a striking manner the cellular tissue of vegetables; it consists of an aggregation of cells of a spherical or oval figure, capable in some cases of being separated from each other, each one having a nucleus and nucleolus in its interior; in this condition it occurs in the rudimentary spinal column of the embryo, and in the chorda dorsalis of the Lampern, and of the tadpole of the Toad and Frog; in other animals more highly advanced in the scale, a strong fibrous capsule or sheath surrounds the cartilage cells, and some of the fibres dip in amongst the cells and bind them firmly together. In cases where the entire skeleton is composed of cartilage, as in the Sharks and Rays, a wholly different appearance is presented; the cartilage is firmer, and is composed of cells imbedded in a substance or matrix, which may be strictly termed *intercellular*: the cells are of various shapes, and are provided with granular nuclei; in some points of view they resemble cavities in the matrix, but in sections made under favourable circumstances, the cells may frequently be entirely isolated; this may be seen in vertical sections of the cartilage of the ears of some of the larger mammalia, and is more clearly shown in Preparation Ag41. It may however here be remarked that cartilage presenting the simple structure just described, rarely, if ever, becomes ossified.

Subseries I. *Membraniform Cartilage.*

The membraniform cartilages consist of nucleated cells, either aggregated together without any intervening substance, or, as is more commonly the case, of the same kind of cells imbedded in a fibrous or other matrix. The cells are generally of large size and very numerous, and are most frequently scattered throughout the intercellular substance without any order or arrangement; in some few cases, as in the ears of the Mouse, Bat and other small mammalia, the cells are arranged in one connected layer, they are of a hexagonal figure, and are

of uniform size, as shown in Plate VII. fig. 2; two or more of such layers superimposed as in figs. 3, 4, make up the entire substance of the cartilage of the ear of the Mouse. The following series of preparations will give a good idea of membraniform cartilage in its simplest form.

a. *Cartilage without any intercellular substance.*

A g 1. Portions of the chorda dorsalis of a Lampern, *Petromyzon fluviatilis*, which consist of an aggregation of large, more or less hexagonal cells, each having a small granular nucleus attached to the inner surface of the cell-wall. The cells are so firmly adherent one to the other, that in this preparation there are only one or two examples of cells in an isolated condition. A portion of this specimen is represented in Plate VI. fig. 3.

A g 2. A transverse section of the chorda dorsalis of the Lamprey, *Petromyzon marinus*, including rather more than one-half of the area of the chord. On the outer convex margin of the specimen may be seen the fibrous capsule enclosing the cartilage, within this are numerous elongated cells of small size; on passing towards the centre the cells become shorter and less numerous, and in the very centre they are nearly hexagonal in figure and of large size, their nuclei also are well-displayed; this last described portion bears a great resemblance to the cellular tissue of many vegetables. Some of the cells are represented in Plate V. fig. 1.

A g 3. A transverse section of the entire chorda dorsalis of the same Lamprey. On the outside may be seen a portion of the fibrous sheath in which the chord was enclosed; within this are numerous cells of small size; as we proceed towards the centre the cells become larger and more elongated; in the centre itself is a brown spot surrounded by a mass of cells as small as those near the margin, but having in their neighbourhood a few of large size, and of hexagonal figure. No areolar tissue can be seen amongst the cells.

A g 4. Three transverse sections of the chorda dorsalis of the Paddle Fish, *Planirostra*, all of which exhibit cells of a similar character to those of the Lamprey; they are all firmly adherent to each other, and most of them exhibit their nuclei, but no trace of areolar tissue is to be found in any part of the preparation in connection with the cells.

A g 5. A vertical section of a portion of the chorda dorsalis of the same fish, on one margin of which may be seen the strong fibrous sheath having the cartilage cells adherent to it; these last are of a hexagonal figure close to the sheath, but become more elongated towards the opposite margin.

A g 6. Two transverse sections of the chorda dorsalis of a Chimæra, *Callorhynchus*; one of them exhibits cells nearly as large as those of the Lamprey, whilst in the other, which appears to have been taken from near the centre of the chord, they are much smaller than in any specimen previously described; both sections are without any trace of areolar tissue between the cells.

A g 7. The lower portion of the chorda dorsalis of the tadpole of the Toad, which has been partially withdrawn from the cellular sheath in which it was enclosed; it consists of a series of large cells of a more or less hexagonal figure, as shown in Plate VI. fig. 8; but none of them in their present state exhibit any trace of nuclei. A portion of the sheath, which is of a dark colour, may still be seen at the end of the specimen nearest the name.

A g 8. A portion of the chorda dorsalis from a larger tadpole of the Toad, which exhibits the same structure as the preceding specimen.

A g 9. A transverse section of the rudimentary spinal column of an embryo Trout, which consists of an outer fibrous tunic, having within it a cartilaginous chorda dorsalis, very much resembling in all its characters that of the Lamprey, and other cartilaginous fish.

Although the Trout is an osseous fish, and as such in the adult state is provided with a spinal column of bone, it in common with most, if not all fishes of the osseous type, has in its embryonic condition a cartilaginous chorda dorsalis.

b. *Cartilage in the form of a membrane with equal-sized cells.*

A g 10. The entire cartilage of one of the ears of a long-eared Bat, *Plecotus auritus*, from which the cuticle, and with it the hairs, have been removed from both its surfaces. It consists of a series of hexagonal cells of equal

size, which resemble to a certain extent the tessellated epithelium of the cuticle of the Frog, as shown in Plate VII. fig. 2. Many of the cells exhibit a nucleus, but the Canada balsam has made the specimen too transparent for them to be well seen. The greater part of the surface of the cartilage is composed of a single layer of cells; in the remainder, two, three or more layers are superimposed, which makes the tissue appear very like fat, especially when seen under a low power. Some of the blood-vessels of the perichondrium still remain; they resemble those of areolar tissue as described in Preparations A f 9, 10. A few hairs occurring in groups, with small patches of fat cells at their roots, are to be seen on one edge of the specimen.

A g 11. A similar preparation of cartilage from the ear of another species of Bat, *Vespertilio pipistrellus*, but much thicker than that of the preceding specimen. The cells are chiefly arranged in several layers, and the walls of the upper layer are sufficiently transparent to allow those of the other layers to be seen beneath them, so that the specimen which is represented in Plate VII. fig. 3, resembles very much a mass of fat cells. There are however certain spots in which the cells occur in a single layer; in these the cell-walls will be found much thicker in proportion than those of the preceding preparation.

A g 12. The ear of a common white Mouse, from which a portion only of the cuticle and perichondrium have been removed. It displays the cellular structure of the hairs of the animal, and a cartilaginous tissue similar in some respects to that described in the two preceding preparations, but differing from them in having the cells larger, and also in their being provided with thinner walls. The entire mass of the cartilage is very transparent, and the walls of the deep layers of cells can be seen through the superficial ones, which gives to the specimen a great resemblance to certain forms of vegetable cellular tissue, and also to a thin layer of fat, as shown in Plate VII. fig. 4.

A g 13. The ear of an ordinary Mouse, with both layers of cuticle entire. It exhibits very plainly the pigment cells in the interior of the hairs, and those in the cuticle as well. The cartilage cells, although quite as

numerous, are not generally as well seen as those in the preceding specimen, excepting in some parts near the cut edge, where the cuticular covering has been removed. The cells are arranged in several layers, and very much resemble some of the forms of vegetable cellular tissue.

c. *Membraniform cartilage, consisting of cells imbedded in an intercellular substance or matrix.*

d. *In Cephalopoda.*

A g 14. A transverse section of a portion of cartilage from the inner surface of the mantle of a Cuttle-fish, *Sepia officinalis*; it consists of a semi-transparent substance, in which are imbedded a series of small cells of very peculiar figure; some are circular, others have a more or less oval centre, with canaliculi radiating from it, like the bone-cells of many fishes, as shown in Plate VI. fig. 1. All the cells are nucleated, and those nearest the convex margin of the specimen are the largest and most numerous.

A g 15. A transverse section of cartilage, from the mantle of the same Cuttle-fish; in which are exhibited cells identical in figure with those of the preceding preparation, as well as others of an oval shape and large size; but the most remarkable structure is of a fibrous nature, which occurs about the centre of the specimen, and at first sight appears to consist of elongated masses of canaliculi, coming off from some of the cells, and being as numerous as the tubuli of dentine, and not unlike them in their mode of arrangement. On examining the convex margin of the specimen, however, the structure can be shown to be of a fibrous and not of a tubular nature. In other parts of this preparation, as well as of the preceding, with the single exception now made, the cartilage is perfectly homogeneous.

e. *In Fishes.*

A g 16. Two sections of cartilage from the cranium of the Paddle-fish, *Planirostra*; they consist of a structureless matrix or intercellular substance, in which are imbedded cells of peculiar shapes; most of them are elongated and nearly cylindrical; others are triangular, whilst some few are much larger in the centre than at either extremity; all are provided with nuclei, and the interior of each is full of minute granules. On an average the cells are $\frac{1}{500}$th of an inch in the long, by $\frac{1}{4000}$th in the short diameter.

A g 17. A vertical section of cartilage from the cranium of a Sturgeon, *Acipenser Sturio*, exhibiting numerous cartilage cells imbedded in a structureless matrix. The cells are of a more or less oval and nodulated figure; many of them contain round granular nuclei; their average size is $\frac{1}{600}$th of an inch in the long, by $\frac{1}{1000}$th in the short diameter. See Plate VI. fig. 4.

A g 18. A vertical section of cartilage from the cranium of a Ray, *Raia Batis*; in which are seen masses of oval cells imbedded in a matrix, which under a power of 200 diameters, appears covered with very minute lines. The cells are not arranged uniformly throughout the whole matrix, but occur in clusters of four or more together; all of them contain nuclei, which are generally collected about the middle of each cell.

A g 19. A vertical section of cartilage from the cranium of the same Ray, exhibiting oval cells collected together in masses: the contents of each cell are more abundant than in the former specimen, and form an oval spot in the centre, so that the cell-wall can be plainly distinguished. The matrix of this specimen is much less granular than that of the preceding.

A g 20. A transverse section of the cartilage of the same Ray, taken from near the brain cavity; in some parts of the specimen, and these the most transparent, the same structure may be observed as that which has been described in the two preceding preparations; in the more opaque parts, the masses of cells are large and very abundant, and both the cells themselves and the matrix in their neighbourhood, present a minutely granular structure, which in the mass is of a brown colour: these granules may be considered as the first step towards ossification of the cartilage.

A g 21. A transverse section of the cartilage from the cranium of the same Ray, in which the masses of cells are smaller but more numerous than those in the preceding specimen; but all plainly show that the deposit of the granular matter takes place first in the wall of the cell, and subsequently in the matrix.

f. *In Reptiles.*

A g 22. Four vertical sections of the cranial cartilage of a Lepidosiren, *Lepidosiren annectens*; each of which consists of a structureless matrix, in which

are imbedded cells of a peculiar figure ; some are spindle-shaped, others oval or circular, but all present one peculiar character, namely, that of having a large circular or oval nucleus in their centre, which fills at that part the entire cell ; within this nucleus are enclosed a few very minute nucleoli. Whatever may be the shape of the cell, the nucleus forms the largest and most persistent part of it, being always present, although the wall of the cell beyond it has been destroyed. The average length of the nuclei is $\frac{1}{1000}$th of an inch.

A g 23. Three vertical sections of cartilage from the cranium of a Siren, *Siren lacertina* ; in two of them large oval cells may be seen, each with a nucleus and nucleoli in its centre, as shown in Plate VI. fig. 7. The matrix in these specimens is structureless, but in the third section (which is the lowest when the preparation is placed on the stage of the microscope, with the name towards the right-hand) there may be seen a fibrous-looking structure like that described in preparation A g 15, and, as there mentioned, the fibres appear like tubes given off from the nuclei of the cartilage cells. The average diameter of the cells is about $\frac{1}{800}$th of an inch.

A g 24. A vertical section of cartilage from the cranium of the tadpole of a Toad, *Bufo vulgaris* ; it consists of numerous large cells so closely packed together as almost to touch each other ; in some parts of the specimen there are commonly three cells joined together, each having a granular nucleus ; in other parts, the cells are larger, and each one contains three of the same kind of nuclei ; in these cases it would appear that the three had coalesced, and that nothing remained of the original cells but the nuclei, as shown in Plate VI. fig. 9.

A g 25. A vertical section of the cranial cartilage of the tadpole of a Frog, *Rana paradoxa* ; it consists of peculiarly-shaped cells of a more or less square figure arranged closely together, and having little, if any, intercellular substance between them ; the walls of the cells are very plainly shown, and when the specimen is a little out of focus, they appear as so many white branching lines. In some parts the space between the cells is

broader than in others, as shown in Plate VI. fig. 10, and also presents a white appearance in certain lights. The nuclei are often very faintly shown, and occupy the centre of each cell.

A g 26. A vertical section of cartilage from the sternum of a Frog; it consists of a delicate hyaline substance, in which are imbedded numerous elongated oval cells, having many nuclei within them; one generally being of larger size and more prominent than the rest. A portion of this cartilage is represented in Plate VI. fig. 11.

A g 27. A vertical section of cartilage from the rib of a Crocodile, *Crocodilus acutus*, having a portion of bony matter adhering to one edge; the cells are of peculiar figure, very narrow, and for the most part slightly curved; they are sometimes arranged in rows of three or four, the cells being placed end to end; when this is the case, the entire row is of a curved figure. Each cell is provided with one or more nuclei, which appear to be full of minute granules, and to be of large size in comparison to the cell itself. On that edge of the specimen nearest the bone, the cells are very numerous, and are placed in rows, as in ossifying cartilage.

A g 28. A longitudinal section of the cartilage of the rib of the same Crocodile, in which are seen numerous cells arranged in rows, and also occurring singly; the rows are principally more or less curved, the single cells are oval in shape, and their nuclei nearly fill the whole of their interior. In some parts of the preparation, lines of rather large size may be seen; these, on minute examination, will be found to be composed of rows of cells. This specimen, like the preceding, shows the ossifying process on one edge. A few of the cells are represented in Plate VI. fig. 12.

g. *In Birds.*

A g 29. Four sections of the cartilage of an Albatross, two of which have been made in the vertical, and the remaining two in the horizontal direction; the first two may be known from the others by the small size of the cells, as shown in Plate VII. fig. 1 *a*, whilst the second two exhibit cells of much larger size, with walls extending some distance beyond the nucleus, as shown at *b* in the same figure. In one of the sections there

is a small mass of bone, consisting entirely of irregular granules, and within them may be seen traces of Haversian canals.

A g 30. A vertical section of cartilage from one of the rings of the trachea of a common Fowl, which consists of cells of much smaller size than in the Albatross ; in some parts they are arranged in groups, in others they are scattered more or less irregularly ; the majority of them exhibit very little trace of the cell-wall as extending beyond the nucleus.

A g 31. A vertical section of cartilage from a young Pigeon, in which the cells are of small size, as in the two preceding specimens, but the cell-wall is more plainly seen.

A g 32. A vertical section of cartilage from one of the rings of the trachea of an Ostrich, *Struthio Camelus* ; it consists of numerous small cells imbedded in a structureless intercellular substance. The cells are of smaller size than in either of the three preceding specimens, and their nuclei are much more difficult to make out. The cells are arranged in rows around the margin of the section, and are in these parts more largely developed than in the centre.

A g 33. A horizontal section of the same cartilage, in which the cells are not so plainly seen ; they are very numerous, and scattered about irregularly. From their being of small size, their nuclei can only occasionally be made out with satisfaction. In this and the preceding specimen, the average dimensions of the cells are $\frac{1}{1000}$th in the long, by $\frac{1}{5000}$th in the short diameter.

In consequence of the very early conversion into bone of all parts of the skeleton of young birds, the cartilaginous structures are more rare in this class of vertebrate animals than in any of the others ; and with the exception of the articular varieties, there is scarcely any other part of the skeleton, except the rings of the trachea, from which true permanent cartilage can be obtained ; and not always from this source, as in many birds even the rings are ossified.

h. *In Mammalia.*

A g 34. A transverse section of part of the thyroid cartilage of a Whale, *Balæna*

Boops, upwards of fifty feet in length; it is composed of large spindle-shaped cells, with a considerable amount of granular matter in their interior; in some parts of the specimen, especially near one of the edges, the cells are much elongated; others are of a triradiate figure, resembling very much those of the Cuttle-fish in Plate VI. fig. 1; whilst some few have so many radii, that they might readily be mistaken for the bone-cells of certain species of fish. The intercellular substance is not structureless, but presents throughout a granular appearance.

A g 35. A longitudinal section of the cartilage from the same Whale, exhibiting in its thickest part a large assemblage of fusiform cells, nearly filled with granular matter of a brown colour, whilst in the thinner (which is the part from which the representation in Plate VII. fig. 6 was taken) the cells are of much greater size and less numerous, their shape in consequence can be more easily made out; a few of the radiated variety may be seen, but the principal forms are the elongated and the oval; some of the former are as much as the $\frac{1}{200}$th of an inch in length.

A g 36. A vertical section of cartilage of an Elephant, *Elephas Indicus*, consisting of cells apparently of very large size, and imbedded in a granular matrix; on close examination, that which at first sight might be deemed a large cell full of nuclei, proves to be a cluster of small, more or less triradiate cells, each having a large nucleus composed of a highly refracting substance like fat; as many as twenty of these cells are frequently collected together, and by the coalescence of their walls form one of the large cells, all of which are of a darker colour than the matrix, and like it, of a granular character. When the specimen is a little out of focus, a white margin may be seen around each large cell. A portion of this preparation is represented in Plate VII. fig. 7.

A g 37. A horizontal section of the cartilage of the same Elephant, some parts of which exhibit cells of a similar shape to those of the preceding preparation; but the majority are of an elongated figure, and composed of many of the smaller kind arranged within the larger one; the shape of the former is more or less triangular, and the nucleus appears to be so

large as to distend the central part of the cell. When the large cell is very much elongated its shape is fusiform, and it can be distinctly seen to be made up of a row of smaller ones, the attached cell-walls being sometimes obliterated.

A g 38. A vertical section of one of the rings of the trachea of a Rhinoceros, *Rhinoceros Indicus*; it is composed of cells of a peculiar figure, imbedded in a granular intercellular substance; each cell is provided with a large oval nucleus, within which are a few very minute granules or nucleoli of a highly refracting substance like oil. On the margin of the specimen, the cells are arranged in rows, and they are principally of a form analogous to those of the Elephant, in which many small nucleated cells make up one of the large and fusiform kind.

A g 39. A transverse section of the cartilage of the same Rhinoceros, in which the cells are principally of the same character as those last described in the preceding preparation, viz. three or more small cells arranged end to end and inclosed within a larger one, which, when in focus, is surrounded by a dark margin, but with a light one when out of focus. The intercellular substance is minutely granular, and the cells are arranged in rows.

A g 40. Three transverse sections of the cartilage of the ear of a Rabbit, in each of which may be observed the following points of interest. The outer margin of each is composed of cells of very small size arranged in rows, whilst the centre is occupied by much larger cells, having their long axes placed at right angles to those in the margin; their interior is also occupied with granular matter, amongst which may generally be seen one or more globular masses of highly refractive material like oil. These large cells are nearly equidistant from each other, and are surrounded by a matrix of a fibrous nature, and in those parts where the section has been made very thin, the cells may occasionally be separated from the matrix, proving them to have walls independent of the substance in which they are imbedded. A portion of this specimen is represented in Plate VII. fig. 5.

A g 41. A transverse section of the cartilage from the ear of a Tapir, *Tapirus Indicus*, in which the same kind of structure may be seen as in the preceding preparation, with the exception of the size of the cells, which are much larger than in the Rabbit, and often found detached from the matrix.

A g 42. A vertical section of costal cartilage from the Human subject, in which the intercellular substance is very abundant as compared with any of the other varieties of cartilage before described. The cells are of large size, and are arranged in rows, especially near the margin; their nuclei are clear and transparent as though they were of an oily nature; the intercellular substance is minutely granular.

A g 43. A horizontal section of the same cartilage, in which the cells are seen grouped together, each being provided with a more or less granular nucleus, as shown in Plate VII. fig. 8. In one part of the specimen, a few fibres may be observed similar to those in Preparations A g 15 and 23; they are straight and parallel, and differ in many respects from those of white fibrous tissue; the intercellular substance is minutely granular.

A g 44. A transverse section of the thyroid cartilage of the larynx of the Human subject, in which the cells are very numerous and scattered about irregularly, except at the margin, where they are arranged in rows, having the same direction as the margin. The nuclei of the cells are plainly seen, as they generally occupy the centre, and do not extend so far as to obscure the cell-wall. In some parts of the specimen the intercellular substance is granular, and towards the outer surface is of a fibrous nature.

A g 45. A transverse section of the cartilage of the ear of the Human subject, having cells of tolerably uniform size arranged closely together; in some parts the intercellular substance is of a fibrous nature, and keeps the cells firmly together; in others the cells are more loose, and can occasionally be detached from the matrix. The fibrous structure is very apparent on the edges of the specimen, where it forms the perichondrium. The cells are much smaller in this form of cartilage than in any of the other varieties from the human subject.

i. *Tissues analogous to cartilage.*

Under this head will be included those structures which to the naked eye appear like cartilage, but which on examination will be found to differ from it in many respects, but cannot well be classed under any other of the varieties of the animal tissues.

A g 46. A portion of the oral filaments of the Lancelet, *Branchiostoma lanceolatus*, which consists of jointed tubes, resembling in their structure and configuration some kinds of cartilage. Portions of two of these filaments are represented in Plate VI. fig. 2; the wall of each tube is of considerable thickness, but sufficiently transparent to allow the granular matter and cells contained within it to be examined.

The Lancelet is the lowest member of the class of fishes, and belongs to the cartilaginous family; but in no part of its skeleton is there any tissue approaching nearer the structure of cartilage than these oral filaments. The vertebral column, which in the Myxine and Lamprey is more or less cartilaginous, in this fish consists of a series of discs of a fibrous nature, which are contained in a sheath, and can readily be separated from each other.

A g 47. A transverse section of a vertebra of a fish called Vaagmaer, *Vogmarus Islandicus*: it exhibits four different structures; the first is an outer coating of dense areolar tissue; the second occupies the centre, and consists of a gelatinous substance, somewhat resembling simple cartilage; the third composes the radii which are prolonged from the centre to the circumference; whilst the fourth consists of a firm fibrous structure, occupying all the spaces between the radii.

A g 48. A transverse section of a portion of a vertebra of the same fish, including part of the fibrous capsule and five of the radii; the latter consist of a linear series of thick-walled cartilaginous cells, having a round aperture of communication between each, through which passes a delicate tube or vessel of uniform size; three of the radii are composed of one row of cells, the remaining two of three rows each, all of which are provided with apertures of communication; the structure between the radii is composed of fibres thickly interwoven.

A g 49. A similar preparation, in which two radii may be observed; in both, the apertures and the tube previously described, are present.

A g 50. Sections of a vertebra of the same fish, made in different directions; all of which exhibit more or less plainly the passage of the tube through the apertures in the walls of the cells.

A g 51. Three longitudinal sections of a vertebra of the same fish, showing the radii divided in the direction of their long diameter; they occur in bundles of three or four, and the apertures through which the tubes pass are seen in the walls at nearly equal distances from each other.

Presented by Dr. Macdonald.

k. *Tumours resembling cartilage, called Enchondroma by Müller.*

A g 52. A vertical section of a portion of a tumour, removed by Mr. Hunter from the side of a man's neck; it weighed 144 ounces, and now forms Preparations 197, 198, 199 of the Pathological series. It consists of a series of large nucleated cells imbedded in a firm intercellular substance, which in some parts is structureless, but in others is more or less fibrous; from having been for many years preserved in spirit, both the nuclei and the intercellular substance are of a brown colour. Some few of the cells are very opaque and granular, and appear as if a spurious kind of ossification were about to commence.

A g 53. A vertical section of a cartilaginous tumour removed after death, and now forming Preparation No. 207 of the Pathological series. It somewhat resembles the preceding specimen, but the cartilage cells are more numerous and regular in size; the intercellular substance is in some parts structureless, in others minutely granular, but towards the edges it is distinctly fibrous. The cells are of uniform size, and this specimen cannot be said to differ from many of the preceding, which have been described as true cartilage, but from occurring as a tumour in a nodulated form, and in an abnormal situation, where it was the cause of death, it has received the name of Enchondroma.

A g 54. A vertical section of a tumour, which was removed from the rib of a

man, and is part of a specimen described as Enchondroma by Müller himself, and now forms Preparation 200 of the Pathological series. On first examination by the microscope, it appears as a mass of fibrous tissue with numerous granules or nuclei interspersed between the fibres, but near the thinnest edge of the section true nucleated cartilaginous cells may be seen ; some few of these have small nuclei and thick walls, others have thinner walls and nuclei of large size, which in most cases fill the entire cell ; these are also of a dark colour and very granular, and appear in the first stage of becoming ossified. When the original preparation itself is examined, it may be seen that this process has been completed in some of the nodules, as small points or spicules of bone occur in various parts.

A g 55. Two vertical sections of a cartilaginous tumour of the testicle, each of which exhibits in its centre a small mass of bone ; the greater part however of each specimen is composed of true, more or less oval cartilage-cells imbedded in a structureless matrix. The cells are of small size, and in the neighbourhood of the bone are very closely aggregated together ; still nearer the bone, both the walls and the nuclei are opaque from the deposit of ossific matter ; this process appears not to be confined to the cells exclusively, but to take place in the intercellular substance also, as in several places an osseous ring may be observed inclosing a cartilage-cell. Although the bony matter is of considerable thickness in parts, it exhibits no trace of bone-cells. A portion of this preparation, with the changes commencing in the nuclei of the cells, is represented in Plate VII. fig. 12. *Presented by W. Fergusson, Esq., F.R.S.*

A g 56. A vertical section of one of a series of tumours from the joints of the fingers, which to the naked eye appears to be composed entirely of cartilage, and corresponds to one of the varieties of tumours named Enchondroma by Müller. When examined microscopically, it consists of a series of nucleated corpuscles of a peculiar shape termed " spiked " by Müller, which are imbedded sometimes in a structureless, at others in a more or less fibrous matrix. A portion of this remarkable structure is represented in Plate VII. fig. 11, and the cells, which are smaller than in

any of the other varieties of permanent cartilage of the human subject, excepting those of the ear, will be found to resemble very much the bone-cells of the Lepidosteus and other osseous fishes, in having extensions of their cell-walls in the form of canaliculi. On comparing the representation of these cells with that of any of the others in Plate VI. or VII., it will be seen that the cells in the cartilage of the Cuttle-fish most nearly approach them in shape; and as the class to which this animal belongs is the only one of the Invertebrata in which true cartilage may be said to exist, it would follow therefore that this peculiar form is of the lowest grade of that tissue.

On examining the thin edges of the specimen, many of the cells will be found projecting beyond the matrix; and in some few instances cells may be seen that have been entirely detached from it, as shown in Plate VII. fig. 11. On viewing the specimen with a power of 40 diameters, numerous large holes will be observed in it; these are canals for the passage of blood-vessels which have been divided transversely. The hand from which the preparation was taken had been injected, and a section of one of the tumours, exhibited the course of large vessels through the diseased mass.

A g 57. A similar preparation of Enchondroma, which in some parts exhibits portions of the fibrous tunic of the tumour, and in this may also be seen traces of the blood-vessels. The edges of some of the sections are extremely thin, and in them may be observed many of the cells projecting beyond the matrix; lying loose in the fluid are an abundance of detached cells, which will prove that these, like the round or oval varieties of cartilage-cells, have walls independent of the matrix.

Subseries II. *Articular Cartilage.*

The articular variety of permanent cartilage, as its name implies, is always found in connection with joints, and is employed either as a thin coating upon the extremities of bones engaged in locomotion, or as a mode of union between other bones that do not allow of any movement, as those of the head, pelvis, &c.;

this last variety differs in structure from the first, partaking rather more of the nature of fibro-cartilage, and will be described under that head.

Articular cartilage entering into the formation of the principal joints, has always two surfaces; one firmly connected to the expanded extremity of bone, the other free, smooth and glistening. When separated from the bone, it is found to be highly elastic and flexible, and if broken, which can only be effected with difficulty, the line of fracture appears of a fibrous nature, and invariably occurs in a direction at right angles to its articular surface. In the human subject it is always destitute of vessels except in the fœtal state, being nourished by those of the synovial membrane, which are prolonged for a short distance over its surface, as well as by the vessels of the bone; these last however are separated from it, according to Mr. Toynbee*, by a non-vascular bony lamella, as shown at *a* in Plate IX. fig. 16.

When examined microscopically, articular cartilage, like many of the forms previously described, consists of two distinct structures, the cells and the matrix; the cells are mostly found arranged in groups or rows, and seldom singly; near the attached surface, the rows are disposed with their long axes at right angles to the free surface, as shown in Plate IX. fig. 16 *c*, but towards the free surface in lines parallel with it, as at *d* in fig. 16. The cells when single are of the usual round or oval figure, but when grouped the attached surfaces are flattened, and the terminal cells pointed at one end; their contents are either homogeneous or granular, and in their centre is a mass of granules containing the nucleus, which last is generally most distinct in the cells situated near the free surface.

The intercellular substance or matrix is most abundant near the attached surface; its structure is occasionally homogeneous, but more frequently granular or even fibrous, especially in the hip-joint near the insertion of the ligamentum teres.

The nature of the free surface of articular cartilage has for many years been the subject of dispute with anatomists; some have described it as being covered by a layer of synovial membrane, provided with a coating of epithelial cells; others have denied not only the existence of the epithelium, but of the synovial membrane as well, and state that the cells that have been described as epithelium, are nothing more than flattened cells of cartilage, as shown in Plate IX.

* Phil. Trans., 1841, p. 159.

figs. 21 and 22, and that the representative of the synovial membrane is a thin superficial layer of the matrix, which can be detached from the deeper parts by reason of its filaments being arranged in the same direction as the long axes of the cells. Before the surfaces of articular cartilages become subjected to friction, as in the fœtus, a synovial membrane with its epithelium certainly does exist, but in adult life the latter is undoubtedly absent; some recent researches however of Mr. Toynbee*, would go to prove that the former is always present; this subject will be fully entered into in that part of the Catalogue devoted to the structure of synovial membranes and joints.

The attached surface of articular cartilage, as shown in Plate IX. fig. 16 at *c*, is separated from the true bone *b*, by a non-vascular layer of bony substance *a*, termed by Mr. Toynbee "non-vascular lamella;" this is of a lighter colour than the bone of the shaft, and contains bone-cells nearly as large again. In an injected specimen of adult bone, the non-vascularity of the lamella may be shown by the vessels of the shaft terminating in loops at some little distance, before they reach the newly-formed layer of bone.

a. *Articular Cartilage in Fishes.*

A h 1. A vertical section of the articular cartilage of the lower jaw of a Cod-fish, *Gadus Morrhua*; it consists principally of a fibrous matrix, in which are imbedded rows of cartilage-cells of uniform size; in some parts the matrix appears to be composed of flattened bands or fibres, running in parallel lines with the cells in their substance. In this specimen, the arrangement of the cells is nearly uniform over the whole surface, and consequently no indication afforded which was the articular and which the attached edge.

A h 2. A transverse section of the articular cartilage from the jaw of the same fish, which exhibits a distinctly fibrous structure on its articular surface in the form of a membrane, beneath which may be seen more or less indistinctly an arrangement of small cells in parallel lines; in some few parts the covering of the cells is minutely granular.

A h 3. A vertical section of the articular cartilage from the lower jaw of a large

* London Medical Journal, vol. i.

Plaice, *Pleuronectes vulgaris* ; it consists of a thin layer of cartilage firmly attached to the bony matter of the jaw ; the matrix is distinctly fibrous, and the cells, which are of small size, are disposed in parallel rows at right angles to the articular surface. No distinct arrangement or variation in size of the cells can be said to be at all characteristic of the free surface.

A h 4. Two transverse sections of the same cartilage, both of which are composed of a fibrous matrix, having numerous cells between the fibres. This specimen, like that from the Cod-fish A h 1, exhibits in some parts an appearance as though the matrix were made up of flattened bands arranged in parallel lines, with numerous cartilage-cells either occurring between them, or imbedded in their substance ; the mode of disposition of the cells is very like that in ossifying cartilage.

A h 5. Two vertical sections of the articular cartilage from the lower jaw of a Conger Eel, *Conger vulgaris* ; both exhibit a fibrous matrix, the direction of the fibres being at right angles to the articular surface. Numerous cells disposed in rows occupy the spaces between the fibres, these are best seen in the smaller section ; they may also be observed in the larger one, but the edge of this section, which is slightly concave, exhibits a cellular structure, the cells resembling those of simple cartilage ; their walls however are minutely granular, so that their true shape cannot so well be made out. Both specimens show minute portions of the articular surface, which may readily be known by the great number of the cartilage-cells occurring in a small space.

A h 6. Two transverse sections from the articular surface of the jaw of the same Conger, which are remarkable for exhibiting minute nucleated cartilage-cells of uniform size, their number far exceeding that of any other of the above-described fishes. The shape of the cells is nearly circular, and their average diameter between the $\frac{1}{3000}$th and $\frac{1}{3500}$th of an inch ; at first sight they very much resemble the corpuscles of human blood. Their mode of arrangement is in parallel rows, and by their numbers they obscure all parts of the matrix, except at the edges, where it may be seen either to be like a structureless membrane, or to be composed of a series of flattened bands.

b. *Articular Cartilage in Reptiles.*

A h 7. A vertical section of articular cartilage from the lower jaw of a Lepidosiren, *Lepidosiren annectens*; the part attached to the shaft may be known by some fibrous tissue on its edge; in this neighbourhood the cartilage-cells are widely separated from each other, and disposed in an irregular manner; as we approach the articular surface, which is on the edge nearest the name, the cells are closely aggregated, and those that consist of two or more joined end to end, have their long axes in the direction of the articular surface, a portion of which last remains, and may be distinctly recognized by the number of the cells, and by their arrangement being very similar to that of pavement epithelium.

A h 8. Two oblique sections of articular cartilage from the lower jaw of the same animal, which exhibit a large portion of the cartilage from the surface; this is remarkable for the number and beauty of the cells, which in some parts are much elongated and arranged in lines; the matrix in which they are imbedded is distinctly fibrous; in other parts the cells are more or less oval or quadrilateral in figure, each being provided with a large granular nucleus, in which respect they strongly resemble cells of epithelium. The cut surface of the cartilage may be readily distinguished from the free by the small number of the cells, and the structureless character of the abundant matrix.

A h 9. Two vertical sections of the head of the humerus of a Menopome, *Menopoma Alleghaniensis*; both very much resemble the same part in the Lepidosiren, the cells being few in number at the attached surface, but very numerous near the free. The shape of the cells is either round or oval, and the nucleus large and granular; in all parts, except near the articular surface, the cells are single, but immediately on the edge they are compound, several being enclosed in one large cell-membrane.

A h 10. Three transverse sections of the cartilage of the humerus of the same animal, all of which exhibit the free or articular surface; this presents a very beautiful arrangement of cells of peculiar figure, apparently arranged in fours; all of them are surrounded by a membranous wall of an oval figure, which the four cells nearly fill; and it would appear that the in-

crease in number of the cells resulted from the splitting of the nucleus of the parent cell into two or four parts, each of which in process of growth becomes capable of undergoing a similar change.

A h 11. A vertical section of articular cartilage from the lower jaw of a large Tortoise, the free surface of which is evident to the naked eye, on account of its edge being more opaque and thicker than that attached to the bone. In commencing the examination with the latter, the cells will be found to be few in number and of an oval shape; proceeding towards the free surface they are more elongated, and consist of several small cells joined end to end, each having a very minute nucleus; this character is preserved nearly as far as the free surface, which last however consists of several laminæ of fibro-cartilage, the fibrous element being in the direction of the surface, and having certain areolæ in which the cartilage-cells are arranged. In no other preparation of this series has so thick a layer of fibrous tissue been observed upon the articular surface of the cartilage as in this one. The average length of the cells is about $\frac{1}{2000}$th of an inch.

A h 12. A transverse section of the articular surface of the jaw of the same Tortoise, which exhibits a minutely granular matrix, in which may be seen an immense number of very small cells, most of which present the same character as those of the vertical section, viz. that of the large cells being of a compound nature, or made up of two or more small cells contained within a larger one. The thin and transparent portions of the section belong to the parts of the cartilage which have been divided vertically, and not to the articular surface.

A h 13. Three vertical sections of the head and part of the shaft of the femur of a Frog. The femur of this animal is hollow, and the articular cartilage is firmly fixed upon it. Each section exhibits the mode of connection between the cartilage and the new bone which is in process of formation. The cartilage-cells are tolerably uniform in size, their average diameter being about $\frac{1}{800}$th of an inch; they are most numerous in the neighbourhood of the bone, and many examples occur in which the ossific matter

may be distinctly seen to enclose them; they are also very abundant near the articular surface, in some parts of which they appear nearly in the form of flattened scales. The bone in all three specimens is granular, and exhibits no trace of bone-cells.

A h 14. Transverse sections of cartilage removed from the outer part of the head of the femur of the same Frog; the specimen is remarkable for showing cartilage-cells of large size and in all phases of development; some being single, others double, others quadruple, &c.; the nucleus and nucleoli with granular matter, can well be seen in all parts of the specimen, a character which appears common in all the lower Reptilia.

A h 15. A vertical section of the articular cartilage of the head of the femur of a large Bull-frog, *Rana pipiens*, to which is attached a small portion of the bone of the shaft. The cartilage-cells are of an oval shape, generally arranged in groups of two or more together, their long axes having no definite direction; near to the articular surface the cells are very numerous, and are disposed in rows parallel with it; the cells here also appear much elongated, and are made up of three or more of a small kind joined end to end. The matrix is structureless, but the bone is in process of growth, and at present contains no bone-cells.

A h 16. A transverse section of the articular cartilage of the femur of the same Bull-frog, the free surface of which is covered with cells of various shapes, some round or oval, others of a semilunar figure, this last variety being the most common; they are arranged in groups, and generally speaking the outer ones are of the semilunar kind, and each group presents the appearance of one cell having split up to form the others, and by the increase in growth of the hyaline substance, these newly-formed cells have been separated from each other.

A h 17. A vertical section of the articular cartilage from the anterior part or ball of a vertebra of a Tiger Boa, *Python Tigris*; the layer of cartilage is extremely thin, and appears to be entirely composed of compound cartilage cells arranged one above the other, with an occasional intermixture of fibrous tissue. The large or compound cells are of an oval shape, and

on an average about $\frac{1}{1000}$th of an inch in their long diameter; they contain in some cases upwards of twenty small nucleated cells within them; even the free articular surface appears to be composed of the walls of the containing cells. The bone to which the cartilage is attached is devoid of bone-cells.

A h 18. A transverse section of the articular cartilage from the ball of a vertebra of the same Boa, the surface of which exhibits an arrangement of large compound cells inclosing numerous smaller ones; around the walls of each large cell there may occasionally be seen some fibrous tissue, but not so much as to denote that this form of cartilage is a modification of fibro-cartilage. The large cells are of various shapes, and on close examination in the neighbourhood of the section, many of them will be found lying loose, having been detached from the matrix; in some of these the division into smaller cells can be well seen. Plate IX. fig. 20.

A h 19. Two vertical sections of the articular cartilage of the head of a femur of a Lizard, *Ameiva vulgaris*, which consist of a granular matrix, in which are imbedded numerous small cartilage-cells arranged in groups; many of them are surrounded by a white line indicating a cell-wall, which appears at one time to have enclosed the whole group, and shows that the increase in the number of cells is caused by the splitting up or division of one cell into four or more small ones. The cells near the free surface of the cartilage are larger and more numerous than those in the neighbourhood of the attached surface, and from their being occasionally found singly or in pairs in the latter situation, it would seem that they are of more recent growth. The bony matter is very dense, but exhibits no trace of bone-cells.

A h 20. Two transverse sections of the articular cartilage of the head of the femur of the same Lizard, the free surface of each appearing covered with cartilage-cells of an oval shape, but varying much in size, and exhibiting in a remarkable manner the way in which the larger cells divide into a number of small ones. The first division of the parent cell is into four, each of which is again subdivided into two; before the last

division takes place, a considerable increase of space may be seen between the first four cells, this being due to the growth of the intercellular substance or matrix; this character appears common to nearly all of the class Reptilia.

A h 21. Three vertical sections of the humerus of a small Crocodile, *Crocodilus acutus*. The attached surface of each specimen may be known by having a portion of the shaft still adherent to it; at this edge the cells are of very small size, and are arranged in columns; as we proceed towards the articular surface, the cells are less numerous and disposed without any order; near the surface they are almost as numerous as they were close to the shaft, being so thickly grouped as to render this part of the specimen opaque. The shape of the cells is more or less oval, many of them having one end more pointed than the other; the average length of their long diameter is about the $\frac{1}{2000}$th of an inch.

A h 22. Two transverse sections of the humerus of the same animal, each presenting the articular surface uppermost; this exhibits an immense number of small cells, principally arranged in groups of two or three together; the matrix in some parts is structureless, in others fibrous; where this latter form prevails the fibres appear to constitute a membrane, which in certain spots evidently covers the cells, but in others is beneath them. When these two specimens are compared with the articular cartilage in Birds, they will be found to resemble them in very many points, the chief being the small size of the individual cells, and the more or less fibrous character of the matrix.

c. *Articular Cartilage in Birds.*

A h 23. Three vertical sections of the articular cartilage of the head of a femur of an Albatross, *Diomedea exulans*, with a portion of the bone attached to each; this presents no bone-cells, but is in a granular condition, the granules being of the smallest size in the neighbourhood of the cartilage. The attached surface of the cartilage itself consists chiefly of a granular matrix with numerous small cells imbedded in it, but proceeding towards the free surface the matrix becomes fibrous, and the cells smaller and less numerous; the free surface itself is almost entirely fibrous,

the remains of the cells being very minute, and only occasionally visible.

A h 24. A transverse section of the articular cartilage of the head of the same femur, the basis of which is distinctly fibrous, the fibres interlacing each other in various directions; in some situations very minute cells may be seen, they are chiefly of an oval figure, and their long diameter on an average is about $\frac{1}{2000}$th of an inch; most of them contain both nuclei and nucleoli, the former being of large size as compared with the cell itself. Plate IX. fig. 19.

A h 25. A vertical section of the articular cartilage of the head of a femur of the common Fowl, having a portion of the bone of the shaft attached to it. In this specimen may be seen two kinds of cartilage, the one permanent, the other temporary, the latter being situated nearest the bone, and remarkable for the number of its cells, which are arranged in columns as in the ossifying cartilage of mammalia; in the former the cells are of the compound form, each containing two or more of a smaller kind; this variety of cartilage is the most common, but in the neighbourhood of the free surface the compound character again disappears, and single cells are found; as in the Albatross this surface is fibrous, and in the interspaces of the bundles of fibres the simple cells are very abundant.

A h 26. A transverse section of the articular cartilage from the head of the femur of the same Fowl, the matrix of which is composed entirely of interlacing bundles of fibres, with small simple cartilage-cells arranged somewhat in a linear manner between the bundles; the cells on the free surface are superficial to the fibres, and it appears that the matrix in which they are imbedded is nearly structureless, and that this is produced by the great amount of coalescence of the fibres.

A h 27. A vertical section of the articular cartilage from the head of a tibia of a Turkey, *Meleagris Gallo-pavo*; it is composed entirely of a strong fibrous structure, having a few small cartilage-cells arranged in rows between the bundles of the fibres, which last are disposed in a line with

the shaft of the bone and therefore at right angles to the free surface; a small portion of bone is attached to the concave edge of the specimen; this is fully developed, and presents bone-cells even within a very short distance of the cartilage.

A h 28. A transverse section of articular cartilage from the head of the tibia of the same Turkey, presenting a stratum of bundles of flattened fibres, which are arranged principally in straight lines; certain spaces occur between the bundles, and in these the cartilage-cells may be seen; they are either oval or circular in figure, and in some parts are so thick as to form nearly a continuous coating.

A h 29. A vertical section of the head of the femur of an Emeu, *Dromaius Novæ-Hollandiæ*, in which with the naked eye may be seen three distinct structures, viz. bone at the lower edge, cartilage in the middle, and fibro-cartilage at the upper or convex edge. The bone is in the form of large oval granules without any bone-cells; the cartilage to which it is attached is of the ossifying kind, and remarkable for the number of its cells, which are arranged in close-set lines; the portion of the cartilage presenting this structure is about one-sixth of the breadth of the entire specimen; immediately upon this is seated a thick stratum of ordinary articular cartilage with compound cells, and above all, on the free edge, a layer of fibro-cartilage about equal in breadth to the ossifying portion. The direction of the fibres is at right angles to that of the shaft of the bone, and a portion of the layer is torn up; the cells are very few in number, and are situated between the bundles of the fibres. A few dark spots may be discerned with the naked eye in the neighbourhood of the bone, these appear as canals for the lodgement of vessels, the animal from which the specimen was taken being a young one. Plate IX. figs. 17 and 18.

A h 30. A transverse section of articular cartilage of the head of the femur of the same Emeu, which is composed of bundles of fibres interlacing each other in various directions; the cartilage-cells are so very few in number, and the bundles of fibres so adherent to each other, that it is only on the thin edges that any trace of cells can be seen.

A h 31. A vertical section of articular cartilage from the distal extremity of the tarso-metatarsal bone of an Ostrich, *Struthio Camelus*; like that of the Emeu, it is of considerable thickness, and presents on examination four distinct structures; the first is the bone, which is entirely granular; the second may be termed the ossifying cartilage, and consists of a granular matrix, in which are imbedded compound cells of large size; above this, ordinary articular cartilage may be seen with numerous compound cells much elongated, and having their long diameters parallel with the free surface of the joint; above all is the fourth structure, viz. a thick layer of fibro-cartilage having the fibres branching in all directions. The cells in this situation are very few in number, and only occasionally to be observed amongst the bundles of fibres. The comparatively structureless character of the free edge of this specimen is very remarkable, and proves, to a certain extent, that the tissue which has been described as synovial membrane, may be in some cases nothing more than a condensed fibrous tissue.

A h 32. A transverse section of the articular cartilage from the distal extremity of the tarso-metatarsal bone of the same Ostrich, which, like that of the other birds before described, consists of broad flattened bundles of fibres interlacing each other in various directions, with scarcely a cartilage-cell of any kind to be seen. In some parts of the specimen however, thin scales, somewhat like those of epithelium or of crystals of cholesterine, may be observed; but from their not occurring in any regular order, and being so few in number in comparison with the surface of the cartilage, they may probably be considered as accidental deposits.

d. *Articular Cartilage in Mammalia.*

A h 33. A vertical section of the articular cartilage of the head of the humerus of a Porpoise, *Delphinus Phocæna*, to which a portion of bone is left attached; this, although in parts merely granular, is nevertheless provided with bone-cells. The cartilage in the neighbourhood of the bone contains cells of a compound character, with their long axes placed in the direction of the shaft of the femur; as we approach the free surface, the walls of the compound cells disappear, and the simple cells themselves

become smaller and more numerous, but close to the free surface they are more widely separated and more difficult to define ; many of them also contain small globules of oil in their interior. The matrix is entirely granular.

A h 34. A transverse section of the articular cartilage of the head of the humerus of the same Porpoise, the free surface of which appears covered with myriads of small cartilage-cells arranged so closely together as almost to obscure the matrix, excepting at the edges, where the cells are more widely separated.

A h 35. Two vertical sections of the head of the humerus of an Ox, including the articular cartilage and a portion of the bone to which the cartilage was attached. The bone presents two distinct structures ; one containing bone-cells of the ordinary kind, the other, which is called the non-vascular lamella, and is situated immediately below the cartilage, having bone-cells of a large and irregular size, with very few canaliculi and no Haversian canals ; it is also whiter in colour than the ordinary bone. Upon this last layer the cartilage is seated ; it has at first very few compound cells, but as we proceed towards the free surface they increase both in number and in size, and at the same time are more elongated, as many as twelve simple cells being joined end to end ; on approaching the free surface they become shorter and shorter, until at last nothing but an innumerable quantity of simple cells are seen. These sections more nearly approach to the human articular cartilage in their structure than to that of any of the animals hitherto described.

A h 36. A transverse section of the surface of the articular cartilage from the head of the humerus of the same Ox, which presents numerous simple cartilage-cells of an oval figure, each one containing in its centre a circular nucleus with numerous nucleoli. The matrix in which the cells are imbedded is minutely granular.

A h 37. Three vertical sections of the head of the humerus of a Pig about six months old, each including the articular cartilage, and a portion of the bone to which it was attached. The bone is in process of growth, and

the cells of the cartilage immediately above it are of the compound kind, much elongated and arranged in columns; as we approach the free surface they are shorter but still compound, and preserve nearly an uniform size, except close to the articular surface itself, where they are simple, but elongated in the direction of that surface which is at right angles to their position in the neighbourhood of the bone.

A h 38. A transverse section of the free surface of the articular cartilage of the head of the femur of the same Pig, which appears covered with myriads of cartilage-cells, generally of a semilunar figure, and occurring in pairs, as though an oval nucleus had divided in halves. The wall of the parent cell is not very visible where the cells are most numerous, but can be well seen on some of the thinnest parts of the edge. The matrix is very minutely granular.

A h 39. Three vertical sections of the head of a femur of *Ornithorhynchus paradoxus*, each of which exhibits both the articular cartilage and bone; the latter is perfectly formed in all parts of the shaft, but in the centre of the largest section, as well as on the lower edge of the two others, bone may be seen; this however is in a granular condition. The cartilage close to the bone has compound cells remarkable for the peculiar shape of the nuclei, which are much flattened, and are arranged in a direction at right angles to the bone, but midway between it and the free surface they alter their character, and become like those of ordinary cells; near to the free surface itself they are again flattened in the same direction as they were close to the bone. The matrix throughout is minutely granular.

A h 40. Two transverse sections of the free surface of the articular cartilage of the head of the femur of the same Ornithorhynchus, both of which exhibit cartilage-cells of peculiar figure, arranged closely together. Over the entire articular surface each cell is surrounded by a white line which joins that of the neighbouring cells, whereby a net-work is produced, each mesh inclosing either a simple or a compound cell; in some parts of the specimen the white line passes through the middle of a cell, and

produces an appearance similar to that occurring in the same parts in the lower Reptilia, viz. of the multiplication of cells by the division of the larger kinds into two or four smaller ones.

A h 41. Two vertical sections of the articular cartilage of the head of the humerus of an Echidna, *Echidna Hystrix*, each having a portion of bone adherent to it, which is in a granular condition and contains no bone-cells. The cartilage from the point of its attachment to the bone to its free surface contains compound cells, with their long axes directed towards the shaft of the bone; they occupy the entire breadth of the cartilage, with the exception of a space about $\frac{1}{100}$th of an inch in breadth, which may be said to belong to the articular surface; here the cells are smaller and more numerous, and the direction of their long axes is at right angles to those in the middle of the cartilage. The matrix in this specimen is perfectly structureless.

A h 42. Two transverse sections of the articular cartilage of the head of the humerus of the same Echidna, each of which exhibits an innumerable quantity of cells upon its free surface; the majority of them are oval, others are either round or square; all contain a granular nucleus. At one extremity of the smaller specimen may be seen a membrane which has been torn from that part of the surface of the cartilage situated near the capsule; it exhibits no appearance of cells, and cannot be traced over them; this no doubt is the synovial membrane, and the edge of the specimen happens to be the point of its attachment to the cartilage.

A h 43. Three vertical sections of the head of the femur of a Sloth, *Bradypus tridactylus*, all of which exhibit the entire depth of the articular cartilage, and a portion of the bone to which it is attached. The cartilage is of considerable thickness, but none of the cells present any particular points of interest except those at the free surface, which are small and very numerous. The animal from which the specimen was taken was not full-grown, and in all the sections may be seen the remains of the canals in which the blood-vessels were lodged; they may be known by clusters of small cells arranged in concentric circles.

A h 44. Two transverse sections of the articular cartilage of the head of the femur of the same Sloth, both of which exhibit on their free surface a layer of minutely granular cells of considerable size, all partaking of the more or less common character, viz. that of indicating that their mode of increase is by the division and subdivision of parent cells.

A h 45. Two vertical sections of the articular cartilage of the head of a femur of a Kangaroo, *Macropus major*, both of which exhibit three different kinds of structure, viz. the bone of the shaft, a portion of the non-vascular lamella, and the cartilage attached to the last-mentioned structure. The bone may be known by its canals, around which the earthy matter is deposited in concentric laminæ, and by its bone-cells; whilst the non-vascular lamella is much more transparent than the bone, and contains no canals, but its bone-cells are of very much larger size, and rarely, if ever, exhibit canaliculi; upon this structure the cartilage is seated; it is a very thin layer, and its cells present the usual arrangement of being smallest and most numerous on the free surface.

A h 46. Two transverse sections of the articular surface of the head of a femur of the same Kangaroo, both of which present numerous cartilage-cells of a more or less oval figure; one of the sections however may be noticed as having a delicate membrane extending from one of its edges; this may at first sight appear as synovial membrane; but if its surface be accurately examined, it will be found that even in the thinnest parts traces of cartilage-cells are present.

A h 47. Two vertical sections of the articular cartilage and a portion of bone of the head of a femur of a Rabbit, in which the layer of cartilage is remarkable both for its thinness and for breaking up into fibrous bands, many of which, with more or less pointed extremities, may be seen on the articular surface. The cells of the cartilage are very few in number and nearly all compound, one long cell generally being sufficient to reach from the bony lamella to the articular surface. In the lamella itself, similar cells may be seen, all of which are surrounded by tubes of bony matter.

A h 48. A transverse section of the surface of the articular cartilage from the

head of the femur of the same rabbit. In this specimen there is no trace either of a membrane or of fibrous bands, the whole surface appears covered with compound cartilage-cells of large size, all of which exhibit the mode of increase by the splitting up or division of a parent cell into two or more of a simple kind.

A h 49. Three vertical sections of the head of the femur of a Cat, *Felis domesticus*, each of which includes a portion of bone in addition to the articular cartilage. The former is perfectly developed, and is provided both with canals and bone-cells ; the latter is on an average about $\frac{1}{150}$th of an inch in thickness, its cells are of small but uniform size, and are arranged in rows at right angles to the articular surface ; there is only a very slight difference between their shape at this part and that which they present at the attached surface ; so that the whole thickness of the cartilage may be said to contain cells of nearly a similar kind. The articular lamella is not very distinct, its thickness measures on an average $\frac{1}{500}$th of an inch.

A h 50. A transverse section of the articular cartilage of the head of the femur of the same Cat, the free surface of which exhibits cartilage-cells mostly of an oval shape, and on an average $\frac{1}{2500}$th of an inch in their long diameter ; they are not arranged so closely together as to form a continuous layer, but the spaces between them are about equal in size to that of the cells themselves ; around the edges however larger cells may be seen, some of which present the character so frequently described, viz. the increase of their number by the division of parent cells.

A h 51. Two vertical sections of the head of the femur of a Mole, *Talpa europæa*, including both cartilage and bone ; the former is exceedingly thin, and exhibits cells of uniform size scattered throughout the matrix without any definite order. The latter is perfectly formed, and its articular lamella contains cells so much resembling those of the cartilage, that it is only by their dark colour that they can be distinguished from them.

A h 52. Two transverse sections of the articular cartilage of the head of the femur of the same Mole, both of which exhibit a large number of small

but well-developed cartilage-cells, mostly of a spherical figure, and on an average $\frac{1}{2000}$th of an inch in diameter; in some parts they appear to project above the surface in which they are imbedded. The larger section contains a portion of the bony lamella in addition to the cartilage, and serves to show the trifling difference that exists between the cells of the two tissues.

A h 53. Three vertical sections of the articular cartilage of the head of a femur of a Bat, *Pteropus*, each having a thin portion of bone attached to it. The cartilage-cells mostly occur in pairs; they are of a semicircular figure, and their appearance would denote the recent splitting of the parent cells; the direction of their long axis is not generally towards the articular surface as in many of the other mammalia, but more or less at angles of 45° to it, in all other respects the cells are natural. The bone is fully developed, and the articular lamella wide and well-marked.

A h 54. A transverse section of the articular cartilage of the head of the femur of the same Bat, the free surface of which exhibits numerous more or less semicircular cells, similar to those described in the preceding specimen; in some parts the cells have their flattened surfaces uppermost, in others their edges; in the latter position two or more are joined together, and they then present an appearance similar to piles of blood-corpuscles. The average diameter of the cells is $\frac{1}{2000}$th of an inch.

A h 55. Two vertical sections of the articular cartilage of the head of the humerus of a Woman aged 19, both of which exhibit in a well-marked manner the arrangement of the cells, and the great extent to which many of them are elongated. Portions of the bone upon which the cartilage rests are present, but the articular lamella is so very thin as only occasionally to be recognized, the bone for the most part coming close to the cartilage. In the neighbourhood of the bone the cartilage-cells are few in number, and have their long axes at right angles to the articular surface; they are of the compound kind, and although in some cases as many as twenty simple cells are joined end to end, yet their breadth is not more than $\frac{1}{3000}$th of an inch. Towards the free surface the cells are

larger and mostly single, and are arranged in a similar manner to those in the specimens previously described.

A h 56. Two vertical sections of the articular cartilage of the head of the humerus of a Woman upwards of 70 years of age, exhibiting structures corresponding with those of the preceding specimen. When carefully examined, the following points of difference will be found worthy of notice. The articular lamella is of great breadth, and exhibits numerous large characteristic corpuscles; the cells of the cartilage are longer and more plainly shown; those near the lamella, though not so much elongated as in the preceding specimen, yet afford an indication of splitting longitudinally to form two columns; whilst the arrangement of those near the free surface is more distinctly shown to be parallel with it. The matrix in both preparations is minutely granular.

A h 57. Two transverse sections of the articular cartilage of the head of the humerus of the same Woman, from which Preparation A h 55 was taken; both exhibit on their free surface large cells having small nuclei and often minute nucleoli in their interior; all the cells indicate more or less distinctly the points where a separation into two or more parts has either taken place or is about to do so. Plate IX. fig. 21.

A h 58. A transverse section of the articular cartilage from the head of the humerus of the same Woman from which Preparation A h 56 was taken; it differs in two principal points from the preceding specimen; viz. that of the cells being considerably larger in size, and with very few exceptions without nuclei. Plate IX. fig. 22.

A h 59. Three vertical sections of the articular cartilage from the distal extremity of the first phalanx of the great toe of a young Woman aged 19, all of which exhibit portions of bone, and the non-vascular lamella in addition to the cartilage. When these sections are compared with those from the humerus of the same subject in Preparation A h 55, it will at once be seen that the cartilage of this bone differs from that of the humerus, not only in having all the cells nearly of the same size, but in those near the attached surface being arranged in the same manner as they are at

the free. The articular lamella is very thin and granular, but presents numerous characteristic corpuscles, and the bone below it is perfectly developed and provided with bone-cells.

A h 60. Three vertical sections of the articular cartilage from the corresponding bone in an old Woman, all of which exhibit the same peculiarities in the arrangement of the cartilage as the last described specimen, but have other points of difference that are worthy of notice. The cells of the cartilage are larger and not so numerous as those of the younger woman; the articular lamella is broader, and its characteristic corpuscles much more plainly shown, but the bone in both presents the same structure. A portion of one of these sections is represented in Plate IX. fig. 16.

A h 61. A transverse section of the articular cartilage from the same bone in the young Woman as Preparation A h 59 was taken; the free surface exhibits a large number of cells, most of which are peculiar on account of the thin edges of their nuclei being uppermost. In those cells that may be called compound, or in other words which consist of two or more small cells joined end to end, the nuclei appear as piles of blood-discs, in which point this specimen resembles Preparation A h 55. If the thinnest border of the section be carefully examined, the cells will be found arranged in rows, and the matrix in which they are imbedded to be of a fibrous nature.

A h 62. Two transverse sections of the articular cartilage from the corresponding bone of the old Woman, both of which present similar appearances. The cells are not so numerous, but larger than those of the preceding specimen, and are mostly arranged with their flattened surfaces uppermost; each cell is of the compound form, and contains on an average four nuclei, generally of a semicircular figure, having nucleoli within them. In some parts of these specimens, as well as in the preceding, the cells are arranged in parallel rows, but the fibrous character of the matrix is by no means so apparent as in that of the younger person. Plate VII. fig. 9.

When a careful comparison is made of the articular cartilage in the four vertebrate classes, it will be found that in structure the cartilage of Fishes more resembles that of Birds than either of the other classes, and both are remarkable

for the large amount of fibro-cartilaginous tissue which is present; in Fishes the cells are small, and the matrix in which they are imbedded distinctly fibrous; the same may be said of that structure in Birds, but with this difference, that there is always ordinary cartilage near the bone, while the free surface is in every case composed of fibro-cartilage, which forms a layer of variable thickness over the whole articular surface. In some Birds, as the common Fowl, the fibres are arranged in the direction of the shaft, but in most other cases they are at right angles to it. The articular cartilage of Reptiles is most like that of the Mammalia, and in the Batrachian tribe especially the flattened cells of the free surface are remarkable for their great size and the beauty of their arrangement. Of the articular cartilage of Reptiles, that of the lower jaw of a Tortoise, *Testudo Indica*, as described in Preparation A h 11, approaches in one point to that of Birds in having a thick layer of fibro-cartilage upon its articular surface; a somewhat similar character is also exhibited in corresponding sections from the Crocodile, as described in Preparation A h 21: the most peculiar cartilage however in this class of animals is that from the ball of a vertebra of *Python Tigris*, described in Preparations A h 17, 18; it consists of large compound cells arranged in a more or less delicately fibrous matrix; from this the cells can be readily separated, a peculiarity in which the articular cartilage of this animal differs from that of any of the others previously described. In Mammalia, the specimens from the Ox approach nearest to those of the human subject; and in the latter it may be stated that the cartilages of young persons differ slightly from those of maturer age, as shown in Preparations A h 55 to 62. In the fœtal state, however, the differences in structure are more striking, not only in regard to the articular surface, but in the size and mode of distribution of the cells, as in this condition the cartilage forms the entire articular extremity or epiphysis of all the long bones. This variety is called temporary cartilage from being in process of growth slowly converted into bone, and for this reason will be described in connection with that tissue.

Subseries III.

a. *Vessels of Membraniform Cartilage.*

All the varieties of membraniform cartilage, as before stated at page 97, are invested with a layer of white fibrous tissue termed perichondrium, which in

function is analogous to the periosteum of bone, and serves as a support to the nutrient blood-vessels. The perichondrium may be plainly shown upon the cartilage of the ribs, where it forms a strong shiny-investing membrane; upon its outer surface may be seen the vessels, which are arranged somewhat like those of areolar tissue, the larger trunks following the course of the fibres. When the cartilage is thin, the vessels proceed no farther than the surface; but when it is thick, they are prolonged into canals in the substance, carrying with them an investing sheath of perichondrium. The canals are generally speaking very large in proportion to the size of the vessels, as shown in Plate VIII. fig. 2; and it frequently happens that they get over-distended with injection in parts, whereby a varicose appearance is produced; or a vessel may give way, and the whole canal become filled with injection. This will account for the seeming irregularity in the course and distribution of many of the larger trunks.

A i 1. A portion of the ear of a Rabbit, from which the skin and areolar tissue have been removed so as to display the perichondrium, which presents a fibrous glistening appearance; upon its outer surface may be seen a few blood-vessels, some of which run in the direction of the fibres, whilst others pass through the perichondrium into the cartilage. In their mode of arrangement the vessels much resemble those of areolar tissue.

A i 2. A similar preparation taken from the upper thin edge of the ear of the Rabbit, which has been dried previous to being mounted in Canada balsam; it exhibits a greater amount of vascularity than the preceding specimen. The vessels are arranged upon the surface of the cartilage, and do not penetrate its substance; they are remarkable for their resemblance to those of areolar tissue.

A i 3. A portion of cartilage from the upper part of the ear of a Rabbit of the "lop-eared variety," which has been injected with size coloured with a solution of carmine in ammonia. Some of the vessels are of large size, and may be as plainly seen by the naked eye as by the microscope, but in consequence of the absence of solid material in the fluid injected, the capillaries cannot be well defined. The injection has either infiltrated the tissue or escaped in the process of drying from all the smaller vessels,

but in the larger ones sufficient colouring matter has been left to show their arrangement.

A i 4. A portion of skin with its areolar tissue and perichondrium, which have been removed from the cartilage of the ear of a Cat; it exhibits a rich network of vessels, but those of the cartilage may be known from the others by their large size, and by being the most superficial. The smaller vessels that are deep seated belong to the skin, and to the areolar tissue; they are tolerably regular in their distribution, but those of the cartilage are very irregular, and have mostly truncated extremities in consequence of having been torn away from the tissue in the substance of which they were distributed.

A i 5. A similar preparation from the ear of the Cat, in which the vessels are more numerous, and amongst them may be seen an arrangement of capillaries like those of muscular tissue; these belong to the perichondrium, and their course is in the same direction as the fibres of that investing tissue.

A i 6. A portion of the cartilage of the auricle of the external ear of the Human subject, from which both skin and areolar tissue have been removed. It exhibits a rich network of large vessels, which are arranged very like those of areolar tissue, there being generally two if not three trunks running parallel one to the other. The upper surface of this preparation was the most external in the ear, and its vessels are larger than those on the opposite or internal surface, although the arrangement in both is very similar. Plate VIII. fig. 7.

A i 7. A portion of the same auricle having its internal surface uppermost; this presents an arrangement of vessels similar to those in the preceding specimen, but of much smaller size, and those parts in the latter containing quadrilateral spaces not supplied with vessels, are in this filled up with a minute capillary network arranged in an hexagonal form.

A i 8. A vertical section of the cartilage from a rib of a Calf, in which are seen many branching canals having blood-vessels in their interior; the vessels

are continued from those of the perichondrium: this last may be seen on the outer surface of the specimen; it presents a shiny appearance, and is supplied with numerous blood-vessels which ramify on its outer surface.

A i 9. A similar preparation of the cartilage of a rib of a Calf, in which the vessels of the perichondrium are well-displayed; their mode of distribution is very like that of the areolar tissue; one large trunk only can be seen, in its passage from the perichondrium into a canal in the substance of the cartilage.

A i 10. A portion of the cartilaginous extremity of one of the ribs of a Human fœtus of full time, with its perichondrium attached; the vessels are large and well-displayed; they very much resemble those of areolar tissue. In one part of the preparation some fine capillaries may be seen; these belong to a portion of one of the intercostal muscles which was firmly attached to the perichondrium.

A i 11. A vertical section of the cartilage of a rib of the same fœtus, in which may be seen canals inclosing large irregularly shaped vessels, prolonged from those of the perichondrium; a portion of this tissue invests all the vessels, and is continued even along the most minute branches into which the canals may be said to divide.

Subseries IV. *Vessels of Articular Cartilage.*

In order to arrive at a correct knowledge of the mode in which articular cartilages are supplied with blood, it will be necessary to divide the subject into two parts; in the first place to consider the vessels as they are arranged in the infantile state of existence, or prior to the conversion of the epiphysis into bone; and in the second, as they are found in adult life and old age.

a. *Vessels of Infantile Cartilage.*

Fœtal articular cartilages are supplied with blood from two sources; first, from the vessels situated between the synovial membrane and the cartilage; and secondly, from those which are called articular, being situated as shown in

Plate VIII. fig. 4, at the junction of the bone with the cartilaginous epiphysis. According to Mr. Toynbee*, in the earliest stages of embryonic existence, articular cartilages are not supplied with blood; but as growth proceeds, canals are formed in their substance for the lodgement of large vessels. In these early periods the epiphysis is composed entirely of cartilage; subsequently however bone is developed in its substance, to this the vessels are distributed; in process of growth the whole epiphysis becomes converted into bone, with the exception of a thin layer of cartilage on its surface; as this is taking place, the vessels of the synovial membrane recede from all parts of the articular surface not subjected to friction, and those of the bone are separated from the thin layer of cartilage by a non-vascular lamella.

A k 1. A vertical section of the articular cartilage from the lower end of the femur of a fœtal Wolf, including the entire breadth of the epiphysis; the cartilage-cells will be seen to differ materially from those of adult life; near the articular edge they are small and very numerous, and their nuclei granular; proceeding towards the opposite edge, the cells become larger and more distinct, the nucleus occupying their centre; still nearer the edge they are much flattened, and are arranged in piles one over the other, and granular matter is seen both in the nucleus and the cell wall; and lastly, at the extreme edge both these structures are rendered opaque by the copious deposit of the granules of bone; the nuclei of the cells in this situation are widely separated from each other. In various parts of this specimen may be seen the remains of vessels that have been divided more or less transversely, proving that at this early stage the cartilage is vascular. A portion of this section is represented in Plate IX. fig. 23.

A k 2. A vertical section of the cartilaginous epiphysis of the head of the humerus of a human fœtus of seven months, the end nearest the number being that which was attached to the shaft of the bone. The outer surface is invested in part by synovial membrane, and at the junction of the epiphysis with the shaft may be seen some of the articular vessels, from which large trunks are continued into the canals of the cartilage. This preparation is represented in Plate VIII. fig. 1; and at fig. 2 are shown a few of the canals with the blood-vessels in their interior.

* Philosophical Transactions, 1841.

A k 3. A portion of the cartilage from the head of the humerus of the same fœtus, to which is attached about half an inch of periosteum, exhibiting some of the articular vessels upon that part which is nearest the cartilage. A large trunk is given off from these vessels to supply the cartilage, into the canals of which its branches are prolonged. This part of the prepa ration is situated nearest the number, and may readily be distinguished by the peculiarity of its vessels ; at the opposite end, or that nearest the name, may be seen the straight vessels of the periosteum, which were lodged in the grooves or canals of the shaft of the bone.

A k 4. A vertical section of the head of the tibia of a human fœtus with the epiphysis attached ; on the upper margin of the latter may be seen the vessels of synovial membrane, but in the epiphysis itself numerous vessels are visible, some of which enter at the upper surface, and others between the attached surfaces of the shaft and epiphysis ; these last spring from the articular vessels of the periosteum. In the shaft the Haversian canals may be noticed, some having vessels in them ; and it will be observed that the bone immediately in contact with the epiphysis is white and non-vascular, being the articular lamella first pointed out by Mr. Toynbee. When the edge of the bone nearest the name is in focus, the periosteum appears still attached to the outer wall of the shaft, and its characteristic vessels are well displayed. This preparation is represented in Plate VIII. fig. 3 ; and at *a* may be seen the articular vessels entering the epiphysis, and at *b* the non-vascular lamella.

A k 5. The upper half of a radius of a human fœtus of seven months, which has been vertically bisected. At the end nearest the name may be seen the cartilaginous epiphysis, upon which is distributed a rich network of vessels belonging to the synovial membrane ; they do not enter the epiphysis, but terminate in beautiful loops immediately anterior to that part of it which, in locomotion, would be subjected to friction ; these vessels are derived from the articular network in its neighbourhood, with which also are connected those of the periosteum. The bony shaft is denuded at its lower part ; its surface is grooved, and on it may be seen some of the trunks which are continued into the Haversian canals. This prepa-

ration is represented in Plate VIII. fig. 4; at *a* are shown the vessels of the synovial membrane, and at *b* those denominated articular; the two sets freely anastomose with each other as well as with those of the periosteum.

A k 6. The opposite half of the preceding preparation, in which may be seen the branches of the articular vessels entering between the epiphysis and the shaft to supply the cartilage. The shaft of the bone is also injected, and its vessels running in the Haversian canals are well displayed; all of them it will be noticed terminate at the articular lamella, none being prolonged into the cartilage. From the mode in which the section of the shaft was made, the looped terminations of these vessels cannot be seen, but in other specimens hereafter to be described the loops are very obvious. The articular lamella is of uniform breadth throughout, and is represented at *a* in Plate VIII. fig. 5; the vessels supplying the epiphysis are shown at *b b* in the same figure.

A k 7. The glenoid cavity of the right scapula of a human fœtus of full time, exhibiting on its articular surface the vessels of the synovial membrane, which proceed upon the cartilage as far as the margin of the socket, for the reception of the head of the humerus. These vessels all terminate in loops, the parts forming the loops being in some cases considerably dilated, as shown in Plate VIII. fig. 10. None of these vessels enter the cartilage, but if the opposite side of the preparation be examined, large canals in which vessels are contained may be readily seen, these last being derived from the articular plexus. One small cluster of capillaries will be found to project into the socket farther than any of those on the margin; these also belong to the synovial membrane, but their office is glandular; they will be again alluded to in the description of the synovial membranes and joints. This specimen is represented in Plate VIII. fig. 6, and the gland above mentioned is shown at *a* in the same figure.

A k 8. A preparation consisting of the acetabulum, ligamentum teres, and a portion of the head of the femur of a human fœtus of seven months. The acetabulum, as shown in Plate VIII. fig. 9 *a*, is nearly filled with

capillaries, which are collected together just at the origin of the ligamentum teres; this last they completely invest, and are continued with it to its insertion in the head of the femur, where they terminate in a beautiful series of loops, none of them entering the cartilage. In the head of the femur itself may be seen the characteristic vessels of the cartilage, but they have no connection with those of the ligament, the two systems being distinct from each; the first described belonging exclusively to the synovial membrane, the last to the articular plexus. This preparation is represented in Plate VIII. fig. 9; but in fig. 8, which is a more highly magnified view of that part of the head of the femur into which the ligamentum teres is inserted, the looped vessels are more plainly shown.

b. *Vessels of Adult Articular Cartilage.*

In the adult state healthy articular cartilage is not provided with blood-vessels, but its supply of nutriment is derived from two sources, viz. the articular vessels and those of the synovial membrane, more especially the latter, but neither set ever enters its substance; the one ending in loops immediately without the parts subjected to friction in the movement of the joint, whilst the others are confined to the cancelli of the shaft of the bone, and are separated from the cartilage by the non-vascular lamella before described. In diseased states, however, as pointed out by the late Mr. Liston, blood-vessels are extensively distributed throughout its substance; in this peculiarity articular cartilage agrees with the cornea, crystalline lens and other tissues that are described as non-vascular.

A k 9. A vertical section of the articular cartilage, and a portion of the shaft of a metacarpal bone of an adult human subject, the vessels of which have been injected with size and vermilion. The cartilage may be readily known by its white colour, and the bone by its redness; in the cancelli of the latter may be seen many blood-vessels, which can be traced as far as the white lamella, but not beyond it, none ever entering the cartilage.

A k 10. A similar preparation from an adult human subject, in which the vessels are better displayed; many of them may be traced as far as the lamella, and on arriving there they appear to form loops; none of them pass into

the cartilage. The lamella is broader and more plainly shown in this than in the preceding preparation.

A k 11. A vertical section of the distal extremity of the first phalanx of the middle finger of an adult human subject, which includes both articular cartilage and a portion of bone; in the latter the vessels are injected, and may be traced from the Haversian canals into the cancellous structure situated near the cartilage, but not farther. In this preparation the non-vascular lamella is not so well shown as in the preceding specimens.

A k 12. A vertical section of the external surface of articular cartilage from the head of a metacarpal bone of an adult human subject, exhibiting the vessels of the synovial membrane, which are said to run between that membrane and the cartilage. These vessels are remarkable for the beauty of their arrangement, and after passing in a more or less tortuous course towards the centre of the cartilage, they all end in capillaries having looped extremities, the convex part of each loop being larger than the capillaries which form it, as shown in Plate VIII. fig. 10. None of these vessels ever enter the cartilage.

A k 13. A preparation removed from the opposite side of the head of the same metacarpal bone, exhibiting a different arrangement of the synovial vessels; they have looped extremities, which are not so plainly shown as those of the preceding specimen; but the larger trunks, in their course towards the central portion of the cartilage, give off sets of capillaries which are repeatedly coiled one upon the other, and project slightly above the free surface somewhat in the form of minute villi, or the Malpighian bodies of the kidney; it is to these vessels that is assigned the function of secreting the synovial fluid as well as that of nourishing the cartilage.

c. *Vessels in Diseased Articular Cartilage.*

A k 14. A vertical section of the lower extremity of the right humerus of an adult human subject, including both the cartilage and a portion of the bone of the shaft. The joint being diseased was removed by operation, and the vessels subsequently injected; on examining the free surface of

the cartilage, it was found to be eroded in some parts, and in others nearly destroyed, the articular surface in both cases being more or less vascular. The section exhibits the vessels of the cancelli of the bone passing into the cartilage and anastomosing with others upon the articular surface; these are probably derived from the synovial membrane, and are supported by a fibrous tissue, which in some instances was not only prolonged over the cartilage of this bone, but formed a connecting medium between it and the adjacent portion of the ulna. The great amount of vascularity of the diseased surface is rendered evident to the naked eye.

A k 15. A vertical section of the right condyle of the same diseased humerus, in which the vessels are more plainly shown; the articular cartilage is somewhat eroded on its free surface, and the fibro-vascular tissue described in the preceding preparation is attached to a portion of it. The vessels pass up from the bone into the cartilage, and in the eroded parts join those of the fibro-vascular layer; in the other apparently sound parts the vessels from the bone merely pass into the cartilage, but do not communicate with those of the fibrous layer.

A k 16. A transverse section of diseased articular cartilage from the right condyle of an adult human femur; on one part of its surface may be seen an isolated spot of tolerably healthy cartilage, which may be known by its white colour; but the remainder has been nearly destroyed, and is now covered by the fibro-vascular membrane which appears to be advancing towards the healthy portion, being however separated from it by an elevated ridge; on the opposite side of the specimen to that exhibiting the healthy cartilage, may be seen another portion so much eroded that the vessels in the cancelli of the bone beneath it are very plainly shown.

A k 17. A vertical section of the preceding specimen, made in the direction of its long diameter, and including the entire length of the above described healthy portion of cartilage. One end of the preparation exhibits the fibro-vascular membrane, and large vessels may be seen passing from it into the cartilage; some few also join those in the cancellous structure of

the bone. In the substance of the cartilage are shown a few large trunks which proceed towards the free edge, and there join others derived from the fibro-vascular layer, which appears to be continued over the entire articular surface of the specimen. Plate VIII. fig. 11.

Series V.

Cellular Tissues.

Adipose Tissue and Fat.

The adipose tissue consists of cells or vesicles of a rounded figure when occurring singly, as shown in Plate IX. fig. 2, but more or less oval or polygonal when collected together in masses, as shown in fig. 1. In the adult human subject the cells vary in size from $\frac{1}{250}$th of an inch to $\frac{1}{700}$th; but in the fœtus they are much smaller, sometimes not exceeding $\frac{1}{800}$th of an inch. The walls of the cells are composed of structureless membrane, and their contents consist of a yellowish oily material known as *Fat*. According to Schwann, a nucleus enclosing two or more nucleoli is present in the cells of the early embryo, but is rarely, if ever, found in the adult.

The cells are sometimes arranged in clusters and form a single layer, but most frequently they are collected together into lobules, each being surrounded by areolar tissue, or the lobules themselves may also be aggregated together to form rounded masses of variable size. The areolar tissue not only invests each lobule, but dips in amongst the cells, giving support to the capillary vessels, and serving with them to bind the cells firmly together. There are however certain situations, as in the marrow of bones, where no areolar tissue is present; in these cases the cells are supported by the cancelli of the bones themselves.

In some animals the colour of adipose tissue is white, but in the majority more or less yellow, and in the Newts and some of the other Batrachia it is reddish brown; wherever it occurs it is copiously supplied with blood-vessels, the larger branches being distributed to the lobules, in which they divide and subdivide, and ultimately break up into a number of capillaries forming a

plexus, and enclosing each cell within a vascular loop, as shown in Plate IX. fig. 6.

Fat.—Although all that has been previously described under the head of adipose tissue is commonly termed fat, it will be necessary in this place to draw a distinction between the two ; the adipose tissue consists of closed cells, and the fat is the material contained within them ; this may preserve its fluid state at ordinary temperatures, and is then known as oil ; or it may be more or less solid, and receive the names of lard, tallow or spermaceti :—oil, according to Hunter*, being only found alone in fishes and the Whale tribe ; lard seldom alone, but in common with oil, as in the Hog and Horse ; tallow occurring in all the Ruminantia, and spermaceti only in one species of Whale.

Fat is not exclusively confined to animals, but exists abundantly in the form of oil in the cells of certain vegetables ; in general appearance and chemical composition, the two differ but little from each other.

According to modern chemists, fat consists of a solid and a liquid principle, the former termed *margarine*, and the latter *elaine* ; in all the hard fats, especially that found around the kidneys in the Ruminantia, and known by the name of suet, a third principle is present named *stearine*. These principles do not exist in a pure state in fat, but as acids in combination with a base called *Glycerine* on account of its sweet taste ; in the process of making soap, and also lead plaster, the acids combine with the potash or lead respectively, and the glycerine is set free. This substance, when diluted with three or four times its bulk of water, forms the fluid in which many of the preparations described in this work are preserved. In the fat of old persons, as well as in that from the neighbourhood of diseased parts, a separation of the solid from the liquid elements of fat may take place spontaneously, as shown in Plate IX. fig. 4, in which needle-shaped, crystalline-looking bodies are clustered together in the form of a star in the middle of the cells, whilst the liquid portion or elaine either fills the remainder of the cell, or some part of it having been absorbed, a small quantity of a thinner or more transparent fluid may be discerned between the elaine and the wall of the cell, rendering the latter very evident.

According to Hunter, fat is differently situated in different animals. In many species of fish it is diffused principally throughout the body, intermixed with the

* Physiological Catalogue, vol. iii. p. 210.

muscular tissue, or in the abdomen or mesentery, as in the Sprat, Trout, Salmon, Herring, &c. In others, as the Cod, Whiting, and all the Ray tribe, it exists only in the liver in the form of oil.

In the Reptiles it exists principally as adipose tissue in the abdomen; in the Frog, Toad and Newt, it is found in the form of several long appendages, situated on each side of the spine, each one being attached by one extremity to a fold of peritoneum, and the others floating free in the abdominal cavity. In the Snake it occurs in small oval masses all along the intestines. In Birds it is situated principally between the peritoneum and abdominal muscles, being but sparingly diffused through the interstices of muscles; in some species it exists abundantly under the skin, especially near the tail.

In Quadrupeds having fat, it is found in all parts of the body, not only between the muscles and the muscular fibres, but even in the mesentery, and about the kidneys and heart. In certain animals it is more abundant in one place than another; thus, in the Whales, Hog, Hedgehog and Man, it is in the greatest quantity underneath the skin; in the Whales it does not exist in the abdomen, whilst others have it unevenly mixed, as the Ox, Sheep and Horse; in these animals, however, it is most abundant in the loins and abdomen, especially about the kidneys. In one animal in particular, viz. the Hare, scarcely any fat is ever to be found. There are also some parts of the human subject in which fat never occurs; amongst the more remarkable of these may be mentioned the scrotum, eyelids, and between the rectum and bladder.

In hybernating animals, as the Hedgehog and Dormouse, as well as in the Frog, Toad and Newts, it is deposited in large quantities in the autumn; during winter it is gradually consumed, and by returning spring it has nearly disappeared; the vesicles of the adipose tissue in which the fat was contained however remain, although the fat has been absorbed.

a. *Fat in Invertebrata.*

A l l. A portion of a viscus, probably liver, from the abdomen of a larva of the Goat-moth, *Cossus ligniperda*; it consists of an aggregation of cells mostly of an oval figure, all of which are filled with vesicles of small size, each vesicle having a membranous wall distinct from that of the cell which encloses them; the contents of the vesicles consist of oil of a light

yellow colour. Around one of the large masses of cells may be seen the investing membrane of areolar tissue.

A 1 2. A portion of the muscular wall of the abdomen of a large Cockroach, *Blatta orientalis*, to some parts of which are attached dark elongated masses of a tissue enclosing globules of oil of small size; some of these masses may be observed running by the side of the muscular fibres, nerves and tracheæ, to the sheaths of which they are firmly attached; others are separated from the surrounding textures, and can therefore be well examined; the size of the largest globules of oil is about $\frac{1}{2000}$th of an inch. Covering some of the muscular fibres, and in some cases projecting over their edges, may be seen a continuous layer of hexagonal cells containing an oily matter in their interior; whether these may be considered as belonging to the adipose tissue seems doubtful.

A 1 3. A similar preparation from the Cockroach, in which the dark masses containing the oil-globules and the hexagonal cells before described, are more distinctly isolated from the surrounding structures. Those of the former kind now appear as if they belonged to a glandular organ, such as the liver.

A 1 4. A portion of the tracheal system of a Gideon Beetle, *Dynastes Gideon*, to which are attached some dark masses of a similar nature to those described in the two preceding specimens; they consist of a membranous envelope containing dark granular matter, and numerous globules of oil. The tracheæ are surrounded by this tissue, and the same may be said of the muscular fibres, as on the margins of the fasciculi they exist in connection with the areolar tissue.

A 1 5. A portion of fatty matter removed from the abdomen of a Water Beetle, *Hydrous piceus*; it consists of a mass of cells very much resembling those from the larva of *Cossus ligniperda*, described in Preparation A 1 1, each cell having a number of smaller ones in its interior; in connection with the large cells may be noticed crystalline bodies which resemble those from old fat of the human subject, not only in size, but in being needle-shaped, and in some cases grouped together in the form of a star.

A 1 6. A portion of the ovarium of a Lobster, *Astacus marinus*: it is of a bright red colour, and consists of an aggregation of cells, amongst which are inclosed numerous globules of oil. With this single exception, nothing approaching the character of fat was to be found in the Lobster.

A 1 7. A portion of the mantle of an Oyster, taken from the neighbourhood of the liver; on one of its thin edges it exhibits a cluster of cells containing oil, the other parts are occupied with very minute granules, which are so abundant as to render turbid the fluid in which the preparation is mounted.

A 1 8. A portion of the liver of a Cuttle-fish, *Sepia officinalis*, which consists of an aggregation of cells mixed up with oil-globules of various sizes. After a careful examination of the tissues of this animal, none could be found to contain fat except the liver; in this particular therefore the Cuttle-fish resembles the Lobster.

It would appear from the above-described series of preparations, as well as from many others not included, that no true adipose tissue is present in invertebrate animals, their fat being in the form of oil, which is principally contained in the liver or other glandular organ.

b. *Adipose Tissue in Fishes.*

A 1 9. A portion of peritoneum from the neighbourhood of the gall-bladder of an Eel, *Anguilla acutirostris*, containing within its folds a small mass of adipose tissue; it is composed of more or less oval cells filled with a whitish oily fluid. The diameter of the largest cells is $\frac{1}{400}$th, and that of the smallest about $\frac{1}{1000}$th of an inch.

A 1 10. A portion of a fold of peritoneum from the neighbourhood of the duodenum of a large Conger Eel, *Conger vulgaris*, exhibiting between its layers a large collection of hard fatty matter of a rich orange colour; some portions consist of oval bodies like the ordinary adipose cells, others of minute spherical globules of oil, but some few of the portions are elongated and branched like blood-vessels. Many of the hard oval masses have a deposit in their interior of a dark brown substance.

A l 11. A transverse section of a portion of the vertebral column of a Lamprey, *Petromyzon marinus*; it consists of a fibrous network inclosing a large number of cells of adipose tissue of nearly equal size; they are so firmly attached to the fibrous investment as to be with difficulty detached from it.

A l 12. A similar preparation which was soaked in æther prior to being mounted; it exhibits very plainly the investing fibrous tissue, and the membranous walls of the fat cells, the fat itself having been dissolved by the æther.

A l 13. A portion of the liver of a Cod-fish, *Gadus Morrhua*, consisting entirely of secreting cells and innumerable globules of oil. Plate IX. fig. 3.

A l 14. A portion of peritoneum from the abdomen of the same Cod, inclosing a mass of cells of adipose tissue; these are of an oval or spherical figure, and are firmly bound together by areolar tissue. Little, if any, adipose tissue is to be found amongst the muscular substance of this fish.

A l 15. A portion of adipose tissue removed from between the muscles of a Sturgeon, *Acipenser Sturio*; it consists of cells of the usual shape and figure containing a bright yellow oily fluid.

c. *Adipose Tissue in Reptiles.*

A l 16. One of the two masses of adipose tissue obtained from the abdomen of a Tree Frog, *Rana viridis*; it consists of a slender pedicle, to which are attached twelve finger-like processes, each one being composed of an investing membrane inclosing a large number of nearly equal-sized vesicles full of oil. This specimen was removed from the animal in the autumn, and may therefore be said to have reached its full size.

A l 17. A portion of one of the fimbriated masses of fat from a Newt, *Triton cristatus*, obtained during the summer; it is of a rich brown colour, and exhibits an investing membrane inclosing a number of vesicles, most of which have become flattened in consequence of the absorption of their contents.

A l 18. A portion of one of the fimbriated masses of fat from the peritoneum, immediately above the left testicle of a Frog, *Rana temporaria*, obtained at the commencement of winter; it consists of a mass of well developed oval cells, completely full of a rich yellow oily fluid. The diameter of some of the largest cells exceeds $\frac{1}{200}$th of an inch.

A l 19. A portion of the green-coloured fat obtained from the abdomen of a Turtle, *Chelonia Mydas*; it consists principally of an elastic kind of areolar tissue, having a small amount of adipose cells occasionally intermixed with it; the cells are of the usual shape, and measure in some cases $\frac{1}{120}$th of an inch in diameter, and not unfrequently have crystals in their interior.

A l 20. A portion of areolar tissue removed from the under surface of the œsophagus of a small Tiger Boa, *Python Tigris*, upon which is situated a layer of adipose tissue consisting of very minute more or less spherical cells, which very much resemble those of the cartilage from the ear of the Mouse; their contents appear to be of an oily nature intermixed with granules. Some of the largest cells are about $\frac{1}{1000}$th of an inch in diameter, whilst others do not exceed $\frac{1}{2000}$th.

A l 21. A portion of one of the small oval lobules of adipose tissue found in the mesentery of a Tiger Boa; it consists of a mass of more or less oval cells containing hard fat in their interior. The lobule has been partially injected, and in one part the remains of large vessels may be seen.

A l 22. A portion of a lobule of adipose tissue removed from the abdomen of a Lizard, *Uromastrix*; it is of a rich yellow colour, and consists of cells full of a firm fat mixed with granules; in some parts of the specimen the fat is of a deep brown, and is apparently much harder than that of the lighter portions.

A l 23. A portion of a large lobule of adipose tissue removed from the mesentery of an Alligator, *Crocodilus Lucius*; it consists of a mass of more or less oval cells full of light-coloured fat. The cells vary considerably in size, some being as large as $\frac{1}{250}$th, others as small as $\frac{1}{800}$th of an inch in diameter.

d. *Adipose Tissue in Birds.*

A l 24. A portion of adipose tissue removed from under the skin of an Albatross, *Diomedea exulans*; it consists of lobules of small cells containing a light oily fluid. On account of the pressure to which the cells have been subjected, none of them appear round, but either oval or polygonal, and in no case does the diameter of any single cell exceed $\frac{1}{700}$th of an inch.

A l 25. A portion of adipose tissue removed from the abdomen of a young Goose, *Anser palustris*; it consists of an aggregation of large cells, each having in its interior either a stellate mass of needle-shaped crystals or a circular granular body, which appears to be one of the stages towards the formation of a mass of crystals. The average diameter of one of the cells is $\frac{1}{200}$th of an inch. The portion of fat from which this specimen was taken was solid and hard at 50° Fahrenheit, but when brought into a room at the temperature of 60° it began to melt.

A l 26. A portion of adipose tissue of a young Duck, *Anas Boschas*, which is of much firmer consistence than that of the Goose, and consists of cells tolerably uniform as to size, containing in their interior a yellow oily fluid mixed with a few granules, but without crystals. The average diameter of these cells is about $\frac{1}{350}$th of an inch.

e. *Adipose Tissue in Mammalia.*

A l 27. Two vertical sections of the subcutaneous fat from the abdomen of a young Porpoise, *Phocæna communis*. This tissue is known as Blubber, and consists of a strong network of areolar tissue inclosing the adipose cells, which are tolerably uniform in size, and filled with oil of a dark yellow colour. A few traces of injected blood-vessels may occasionally be observed in the areolar tissue. The average diameter of the cells is $\frac{1}{1000}$th of an inch.

A l 28. A vertical section of one of the flukes of the tail of another Porpoise, more minutely injected than the preceding specimen. The fibrous tissue is very abundant and strong, and parallel with the fibres the blood-vessels run, these are covered on all sides with adipose cells, which vary con-

siderably in size, the largest being about $\frac{1}{700}$th, whilst others are as small as $\frac{1}{2000}$th of an inch in diameter.

A l 29. A vertical section of the Blubber taken from beneath the integuments of a Whale, *Balæna mysticetus*, which has been partially injected; it consists of a series of large cells formed by areolar tissue, in which the adipose vesicles are contained; these cells are $\frac{1}{40}$th of an inch in diameter, and are very evident to the naked eye, and the preparation very much resembles that of a portion of lung; the adipose tissue contained within them is sufficiently hard to be detached from the cell in a solid mass; this, when examined with a power of 200 linear, is found to consist of large adipose vesicles containing crystals; the hardness of the fatty matter in this specimen may be owing to its having been preserved many years in spirit.

A l 30. A portion of the Blubber of a Spermaceti Whale, *Physeter macrocephalus*, which consists of spherical cells, varying considerably in size, some being as large as $\frac{1}{70}$th of an inch, others about $\frac{1}{800}$th in diameter; most of them have either a cluster of needle-shaped crystals, or small granular uniform bodies in their interior. In some of the thickest parts of the specimen the crystals are very abundant, and all trace of the original cell-walls has disappeared; each cluster of cells now appears like one large cell, all being surrounded by areolar tissue.

A l 31. A transverse section of hard fat known as *suet*, obtained from the region of the kidney of an Ox; the cells are of polygonal figure from pressure, and their contents solid and granular, and so firm as to alter but slightly in shape when divided by the knife. Very thin sections of this fat could be easily made, but a portion of the same tissue from the kidney of the Hog and known as *lard*, yielded so much to the knife as to exhibit but little trace of cells.

A l 32. A similar preparation of suet of the Ox, in which many of the cells have been detached from each other, and may be seen singly; they present every variety of shape, and their colour varies according to the thickness of their contents.

A 1 33. A portion of areolar tissue taken from under the skin of a human fœtus of five months; in connection with it may be observed one part more opaque than the rest; when this is carefully examined, it will be found to consist of a mass of cells; those forming the superficial layer are of a rounded figure and without nuclei, and may be considered as belonging to adipose tissue; they are $\frac{1}{1300}$th of an inch in diameter, and their contents consist of a highly refracting material like oil.

A 1 34. A small lobule of fat, obtained from under the skin of a human fœtus of full time; it consists of spherical vesicles, on an average $\frac{1}{400}$th of an inch in diameter; the fat contained within them presents a granular appearance, so that where two or more cells are superimposed, the mass is very opaque; a few of the vessels distributed to the lobule are injected, and may be traced to the smallest masses, into which the lobule is divided.

A 1 35. A portion of a lobule of fat taken from under the scalp of an adult human subject; it consists of a series of cells of an oval or circular figure, as shown in Plate IX. fig. 1, all of which contain a light-coloured fat; the cells, it will be noticed, are much larger than those in the fœtus, some averaging $\frac{1}{250}$th of an inch, others being as small as $\frac{1}{800}$th. The cells are firmly connected together by areolar tissue.

A 1 36. A portion of adipose tissue taken from the neighbourhood of a tumour, removed from an aged Woman; it consists of cells, having in their interior stellate masses of needle-shaped crystals of margaric acid, as represented in Plate IX. fig. 4, and of the same nature as those described in many of the preceding preparations.

f. *Adipose Cells from the interior of bones termed Marrow.*

A 1 37. A transverse section of marrow obtained from the medullary cavity of the central portion of the humerus of an Ox; it consists of cells mostly of an oval shape, which are full of a hard fat quite as firm as that from the suet of the same animal described in Preparation A 1 31. The only other peculiarity about this structure is that the cells are not connected together by areolar tissue.

A 1 38. A portion of marrow obtained from the lower extremity of the right metacarpal bone of an Ox, which differs considerably in firmness from that of the preceding specimen. The cells are identical in size with those of the harder marrow, but their contents vary ; in this specimen the fat is liquid, and when once detached from the cells will remain fluid at ordinary temperatures, and is known as "Neat's foot oil." There is no areolar tissue whatever to bind the cells closely together, consequently they may be separated from each other with the greatest ease.

A 1 39. A portion of marrow obtained from the lower end of the humerus of an adult human subject ; it consists of cells of a more or less oval figure containing oil in their interior. These cells do not differ materially in size or shape from those of ordinary adipose tissue, occurring either under the skin or in other situations. It may however be noticed, that the marrow taken from the centre of the bone, or where there are few, if any, cancelli, is much harder than that taken from the cancellated structure at the extremities. This rule holds good of the marrow from most, if not all other animals.

A 1 40. A small portion of marrow taken from the lower extremity of a human tibia affected with *mollities ossium* ; it consists of cells of the usual shape full of very liquid oil. It appears to be a striking character in this disease, that as the bone becomes thin and cancellated, all the cells are occupied by a very fluid marrow, so that mollities ossium might almost be considered as a fatty degeneration of the bony tissue.

A certain amount of adipose tissue is a sign of health, but an absence as well as an excess of it may constitute disease. In addition to the ordinary situations in which adipose tissue may be found, it is often developed in unusual quantities in the form of round nodulated tumours, not unfrequently weighing many pounds, and requiring removal by operation ; in structure these resemble ordinary adipose tissue in every essential particular. There are also instances of common occurrence, in which tissues such as cartilage and muscle, more especially the latter, become converted into fat, or in other words undergo a species of fatty degeneration ; the same tissues, when exposed to certain necessary conditions,

may also be converted into a kind of wax termed *adipocire*. In all these examples traces of the original structures are frequently preserved, and may be recognised after the fatty matters have been separated from them by the aid of maceration in ether. Numerous examples of fatty degeneration will be given in the Pathological portion of this Catalogue.

Subseries I. *Vessels of Adipose Tissue.*

Adipose tissue, as before stated in page 143, is copiously supplied with blood-vessels, the larger trunks being distributed to the lobules, in which they divide and subdivide, and ultimately break up into a number of equal-sized capillaries, which form a plexus and inclose each cell in a vascular loop, as shown in Plate IX. fig. 6 ; each lobule has therefore its own capillary network, and its capillaries seldom anastomose with those of adjoining lobules ; in the Frog and Newt, in the summer, when the fat has been absorbed, the vessels form a much closer network, which is not so characteristic of adipose tissue as when the cells are fully distended.

a. *Vessels of Adipose Tissue in Fishes.*

A m 1. A portion of peritoneum taken from the abdomen of a Cod ; it exhibits over the greater portion of its surface large vessels belonging to the serous membrane ; on one of its edges a close capillary network may be observed ; this belongs to a small portion of adipose tissue which occupied that situation.

A m 2. A portion of peritoneum from the abdomen of a Conger Eel, *Conger vulgaris*, showing a small cluster of adipose cells ; these are chiefly of a spherical figure and of large size ; each cell is inclosed within a capillary ring. The fat in this specimen is of a dark yellow colour.

b. *Vessels of Adipose Tissue in Reptiles.*

A m 3. A portion of one of the masses of adipose tissue obtained from the abdomen of a Newt, *Triton cristatus* ; it consists of a series of cells of a light brown colour, each of which is surrounded by a capillary loop of large size ; the vessels may be seen by a power of 40 diameters or less,

but in order to examine the adipose vesicles, one of at least 100 must be used.

A m 4. A portion of adipose tissue taken from the upper part of the testicle of a Toad, *Bufo vulgaris*; it exhibits a network of capillaries so closely arranged, that they can hardly be said to be characteristic of adipose tissue. The contents of the cells have been entirely absorbed, and it is only in the uninjected parts that the empty cells can be seen.

A m 5. Two masses of fat taken from the abdomen of a Toad in the summer of 1849, both of which exhibit a rich capillary network characteristic of adipose tissue: in consequence of the absorption of the contents of the cells, the capillaries are closer together than they would have been in the autumn; the diameter of the smallest capillary is above the $\frac{1}{2000}$th of an inch.

A m 6. A portion of one of the fimbriated masses of adipose tissue taken from the abdomen of a Frog, *Rana temporaria*, in the summer of 1849; the contents of the cells have in part been absorbed, consequently the meshes of the capillaries are very close together; their diameter considerably exceeds those of the same tissue in the Toad.

A m 7. A similar preparation of adipose tissue from the abdomen of a smaller Frog; the fimbriæ are more elongated than in the preceding specimen; in those portions in which the capillaries are partially injected, may be seen the artery running to the free extremity of the mass, and the vein in the opposite direction; the two vessels lie side by side, but the former is much larger than the latter; in the parts well-injected, the artery and vein are hidden by the capillary network.

A m 8. A portion of adipose tissue taken from the abdomen of a Frog in the winter season; the mass is much larger and more fully distended than either of the preceding specimens. The capillary network has also larger meshes, and in those portions which are partially injected, the encircling of the cells by a capillary loop may be well seen.

A m 9. A portion of adipose tissue removed from the abdomen of a Snake,

Coluber natrix, displaying to great advantage the arrangement of the capillaries of adipose tissue. On the thin edges, where the vessels are only partially injected, the cells may be seen, but from the preparation having been soaked in turpentine, all trace of the fat has disappeared.

c. *Vessels of Adipose Tissue in Birds.*

A m 10. A portion of areolar tissue taken from beneath the skin of a Pigeon, remarkable for exhibiting a large number of minute lobules of adipose tissue, the vessels of which may readily be discerned by the naked eye. The lobules vary considerably in size, but their shape is mostly oval; the capillary network is very fine, and as both arteries and veins are injected, they may be occasionally seen in their course to and from the lobules.

A m 11. A larger portion of areolar tissue taken from the same Pigeon, in which the course and distribution of the arteries, veins and capillaries are better shown than in the preceding specimen. A practised eye can readily perceive that one or more nerves were present with the vessels in this preparation, as not only are the capillaries of the neurilemma present, but both sides of the latter are provided with small elongated lobules of adipose tissue, by which the course of the nerve is more clearly defined. In this particular the specimen corresponds with that of A f 9.

A m 12. A portion of adipose tissue attached to the skin of the neck of a Rook, *Corvus frugilegus*; the cells are of an oval or circular figure, but their fat has been extracted by turpentine. They are arranged in a lobulated form; the large blood-vessels supply the principal lobules, and split up in them so as to form a capillary plexus of great beauty surrounding each cell with a vascular loop. *Presented by Alexander Hett, Esq., M.R.C.S.L.*

A m 13. A small portion of adipose tissue obtained from beneath the skin of the foot of an Ostrich, *Struthio Camelus*; it consists of cells of small size, being on an average not more than $\frac{1}{300}$th of an inch in diameter, and having large vessels running between them; the capillary network is in some parts very well seen, and although the vessels are not always perfectly filled, yet enough of them are present to show that their mode of arrangement is characteristic of adipose tissue.

d. *Vessels of Adipose Tissue in Mammalia.*

A m 14. A vertical section of the skin of a young Porpoise, *Phocæna communis*; it consists of bundles of strong fibres, between which large vessels take their course; these are arranged so as to form a coarse network with quadrilateral meshes, from the inner angles of which capillaries are given off to surround the cells; these last are arranged in rows on each side of the vessels, and when the network is perfectly filled, the loops around the cells appear as so many links of a chain.

A m 15. A vertical section of the same skin, which has been dried prior to being mounted in Canada balsam; it exhibits the arrangement of the vessels more plainly than the preceding specimen, but the fat cells are not so well displayed. In one or two parts the capillary network is perfect, the quadrilateral spaces above alluded to as being formed by the large vessels, are in this specimen nearly all filled up.

A m 16. A vertical section of the skin of the same Porpoise, taken from the under surface of the body, and exhibiting papillæ and cuticle in addition to the blubber. The vessels of the papillæ form a series of loops, but those of the blubber resemble to a certain extent the vessels of adipose tissue in other animals; it will however be readily remarked, that the most perfect arrangement of capillaries exists in the layer of blubber immediately under the papillæ.

A m 17. A vertical section of the pad of the foot of a Dog, *Canis familiaris*; it exhibits on its free surface a row of beautiful papillæ, each one supplied with looped blood-vessels; below these are the capillaries of the sweat glands, and still lower the lobules of adipose tissue, each having its characteristic network of capillaries; the capillaries of the former may be readily known from those of the latter by the closeness of their network, and by the small and nearly uniform shape of the glands themselves.

Presented by Mr. C. M. Topping.

A m 18. A small portion of the skin from the leg of a Pig only two days old; the adipose tissue is arranged in a thin layer, having its characteristic network of capillaries; when fully developed it is termed bacon, and

holds a somewhat analogous situation to that of the blubber of the Porpoise, but the adipose cells in these two structures are very differently arranged, and the strong fibrous tissue of the Porpoise is absent in this animal. *Presented by Alexander Hett, M.R.C.S.L.*

A m 19. A portion of the mesentery of a Cat, the vessels of which have been injected with size coloured by a solution of carmine in ammonia, a plan first adopted by Mr. Alfred Smee. Accompanying the larger vessels may be noticed masses of fat, which are more plainly seen when the preparation is held towards the light; on a closer inspection, all the other parts of the mesentery will be found tinged with the carmine. When the specimen is examined with a power of 100 linear, some portions of the fat may be noticed perfectly dyed with the carmine, and others having a supply of capillaries equal in size to those described in the preceding specimens, and similar in arrangement to them; whilst in a few parts more than usually small filaments are seen running amongst the cells of fat; these, from being supposed to be vessels, and being much smaller than capillaries, have been termed *vasa adipis* by Mr. Smee, who considered them analogous to the *vasa serosa* of the older anatomists. That this appearance is produced either by the mere escape of the injection amongst the fat cells, or by a staining of the areolar tissue between them, is very evident, for the whole of the white fibrous tissue, being impregnated with carmine, looks very much like a vascular network; and if these supposed vessels be compared with the true capillaries of the cells, which are visible in some parts, the difference between them is very striking. *Presented by J. S. Bowerbank, Esq., F.R.S.*

A m 20. A similar preparation of mesentery of the Cat, in which the adipose tissue is more deeply tinged with carmine; it exhibits in certain portions a partial injection of the adipose capillaries, but the network is in no instance so complete as in the preceding specimen.

A m 21. A similar preparation of mesentery of the Cat, having the adipose tissue very deeply tinged with carmine, although very few of the capillaries are filled.

A m 22. A portion of the pleura costalis of a human fœtus at full time, having upon its upper surface two or more lobules of adipose tissue, which may readily be known by their great amount of vascularity. The capillary network is arranged in the usual manner, but the value of this specimen consists in having many masses of cells with their fat still remaining in them; these may be known by their white appearance, and when examined with a power of 200 linear, the capillary loop around each of the cells is better shown than in any of the preceding preparations. A small portion of this specimen is represented in Plate IX. fig. 6.

A m 23. A vertical section of the skin of the arm of a human fœtus at full time, exhibiting numerous small lobules of adipose tissue; each one is supplied with a rich network of capillaries, which are arranged in the usual form, but the meshes or spaces between the vessels are finer than they are in the adult, which may readily be accounted for, as the size of the cells is much smaller in the young than in the full-grown individual.

Presented by Alexander Hett, Esq., M.R.C.S.L.

A m 24. A vertical section of the skin of the finger of an adult human subject, exhibiting the capillaries of the papillæ and sudoriferous glands in addition to those of the adipose tissue; the capillaries belonging to the structure last named may be easily distinguished from the others by their occupying the greatest portion of the specimen, and presenting a more or less regular hexagonal network: the capillaries of this preparation are not much larger than they are in the preceding, but the meshes of the network are on a much coarser scale.

A m 25. A vertical section of skin taken from a diseased ankle of a woman of middle age, which is remarkable for the thick layer of adipose tissue situated below the dermis; the vessels have been injected with size and vermilion, and exhibit very clearly the distribution peculiar to adipose tissue; one or two papillæ may be seen on its free margin.

A m 26. A similar section of human skin, exhibiting the capillaries of the adipose tissue as distinctly as those in the preceding specimen; the papillæ on the free surface are also more plainly displayed.

A m 27. A thinner section of the same skin, which, when viewed with a power of 200 linear, shows at one view both the fat vesicles and the vessels surrounding them. When this, as well as the two preceding preparations, are viewed with the power above mentioned, the capillaries will be found to vary in size in proportion to the quantity of injection which they may contain.

A m 28. A portion of areolar tissue removed from between the muscles of an adult human subject, exhibiting the capillary network of several small lobules of fat; each lobule is distinct from that of its neighbour, and its free margin of a semicircular figure; in some cases both the artery and vein which supply it can be seen, most frequently the latter, which may be known by its large size. When viewed with a power of 40 diameters, the general arrangement of the capillaries can be well made out; but if a power of 200 be employed upon it as a transparent object, a few of the adipose cells are occasionally to be discerned, the greater number of them having been rendered so transparent by turpentine as to be nearly invisible. One of the most characteristic of the lobules is represented in Plate IX. fig. 5.

Series VI.

Cellular Tissues.

Pigment.

In the animal as well as in the vegetable kingdom, the pigment or decided colouring matter is contained in the interior of cells. In both it may be in a fluid or in a granular state; abundant instances of the former occur amongst vegetables, and the contents of the blood-corpuscle and of the fat vesicle may be adduced as familiar examples of the same in animals, whilst the latter or granular condition is common in animals, but extremely rare in vegetables; and when present the prevailing colour is green.

The cells containing the pigment have walls of structureless membrane; they

vary much both in size and figure, the most common form being hexagonal, as shown in Plate IX. figs. 7, 8, 9, which are representations of the pigmentum nigrum of the choroid coat of the eyes of animals, or they may either be elongated and branched, as shown in fig. 14; or the branches may be so numerous as to give the cells a stellate appearance, as shown in fig. 15. In newly developed cells, as shown at *a a* in figs. 10, 11 and 14, the nucleus may be observed as a white spot occupying the centre; but in older specimens it is seldom plainly seen, having either disappeared, or being hidden from view by the great abundance of the pigmental matter.

The solid pigment consists of granules either of a spherical or more or less oblong figure, and on an average not more than $\frac{1}{20000}$th of an inch in diameter; when viewed separately they appear quite transparent, but when collected in little masses, either in or out of the cells, they are more or less black, the depth of shade depending upon the numbers aggregated together in a certain space. If the cells be ruptured the granules escape, and, like many other forms of minutely divided matter, will exhibit a rapid molecular movement; this, according to Schwann, may be occasionally observed even in the interior of the cells themselves. The granules consist of a peculiar animal principle, the chief constituent of which is said to be carbon, and their colour is not capable of being removed by the ordinary mineral acids; chlorine, however, is employed to decolorize them, but there is a certain kind of pigment, presently to be noticed as occurring in the human skin, that will even resist this powerful agent. The principal seat of pigment in animals is in the cuticular layer of the skin, in which situation it occurs in the form of hexagonal cells like those of epithelium, and known in the Negro as the *rete mucosum*, as shown in Plate IX. figs. 12 and 13; this is not a distinct layer of the skin as many persons have imagined, but only the last layer of cuticle deposited, the cells of which contain granules of pigment; similar cells are present in the cuticle of the white races of mankind, and the difference in quantity of the pigment in them gives rise to all the varieties of shades of colour which the skin of this portion of the human race presents. In Albinoes the cells can be as plainly seen as in the black parents of these individuals, but the pigment granules are either absent, or if present, but slightly coloured.

In the choroid coat of the eyes of animals, the Mammalia more especially, the cells are generally of uniform size, and form a beautiful expanded membranous

layer over the rich network of vessels of the choroid; their shape is mostly hexagonal, but between the choroid and sclerotic they are elongated and branched, as shown in fig. 14, and have a light circular spot or nucleus, *a*, in their centre.

In Fishes and Reptiles, the cells in the skin and peritoneum frequently present a stellate appearance, as shown in fig. 15, and the prevailing colour of the pigment is generally either dark brown or black; but in the iris of some Reptiles, as the Boa Constrictor, it is often of silvery whiteness.

The pigment above mentioned as existing in the skin of Fishes, must not be confounded with that giving colour to the scales and choroid membrane; this will hereafter be described, as the two differ in many essential points, the former being cellular, and the latter not unfrequently having an appearance of a crystalline formation.

Pigment is not exclusively confined to healthy structures, it not unfrequently occurs in diseased growths; as for instance, in that form of medullary tumour called from its colour *Melanosis*, which consists principally of cells full of black granules. It may also be thrown off from the skin in the form of scales, as described in Preparation A n 26.

Pigment is also developed rapidly in certain situations, and after the removal of the exciting cause it may again disappear; as for instance in the areola round the nipples during pregnancy, and in the brown spots known as *freckles*, which occur in the skin of certain individuals after exposure to a summer's sun.

a. *Pigment in Vegetables.*

A n 1. A portion of a petal of a *Pelargonium*, consisting of cells for the most part full of colouring matter of various shades of pink or crimson; in many of the cells the deepest tints occur on the margins; other examples of Pigment in Vegetables will be found in Preparations E 1, 2, 3.

b. *Pigment in Cephalopods.*

A n 2. A portion of the cuticle of a Cuttle-fish, *Sepia officinalis*, in which may be seen large more or less oval spots full of granules of a dark purple pigment; some of the cells are ruptured, and the granules have escaped.

c. *Pigment in Fishes.*

A n 3. A portion of the skin of a Lamprey, *Petromyzon marinus*, exhibiting a large number of beautiful stellate pigment cells, which in figure are very much like the bone-cells of some of the Batrachian reptiles. The skin itself appears to be composed of two layers of flattened fibres, the one arranged at right angles to the other, so that on the whole it resembles a textile fabric. Two of the cells are represented in Plate IX. fig. 15.

A n 4. A portion of the skin of a Plaice, *Pleuronectes vulgaris*, exhibiting to the naked eye a large red spot; when this is examined with a power of at least 100 linear, it will be found that the red colour is due to the presence of minute irregular cells scattered in profusion between others of large size, which are of a black colour and stellate figure. In the parts containing the largest number of the black cells, the red spots are most abundant. At the end of the preparation nearest the name may be seen four scales arranged in a row.

A n 5. A portion of the skin of a Trout, *Salmo fario*, about 4 months old, exhibiting a large number of black pigment cells; these are most numerous on the dorsal surface, which is the part nearest the name, and most of them are becoming stellate by the growth of numerous branches or canaliculi from the central portion or body, whilst those on the opposite or abdominal surface are fewer in number and circular in figure.

d. *Pigment in Reptiles.*

A n 6. A portion of the skin of a Newt, *Triton palmatus*, the dermis of which exhibits a number of circular follicles, some empty, others full of a dark-granular material; in the cuticular layer may be observed numerous small stellate pigment cells, which are arranged so as to form a network composed of two sets of rings, one set being situated around the follicles above alluded to, and the other around the interspaces between the follicles; the latter are of smaller size than the former, and are evidently follicular; they appear as so many white spots when only a superficial examination is made of them. The arrangement of the pigment cells above described exists only in darkest parts, and may be said to be perfect; but if the lighter portions be examined, the cells will be found both

fewer in number and quite circular, but they exhibit a similar order of deposition to those more perfectly developed. To the naked eye, the masses of pigment cells give the skin a marbled appearance, and in those parts in which it is absent the follicular structure can be observed.

A n 7. A preparation of the skin of the same Newt, exhibiting a much larger collection of the pigment cells; in some of the darkest spots, the cells not only surround the margins of the follicles, but their branches radiate towards the centre of each, so as to give it an inner margin of a lighter brown colour than the outer one.

A n 8. A portion of the web of the foot of a Frog, *Rana temporaria*, exhibiting numerous pigment cells, mostly of a stellate figure; in this part of the body they are not collected into masses as in the Newt, but generally occur singly.

A n 9. A portion of the skin of the tadpole of a Frog, exhibiting stellate pigment cells of larger size than those in the preceding specimen; they closely resemble the cells of the Lamprey, Trout, and fishes generally.

A n 10. A small portion of the iris of a Tiger Boa, *Python Tigris*, having its inner surface uppermost; it exhibits a collection of stellate pigment cells, the contents of which present to the eye a silvery white appearance when viewed by reflected light, but are nearly black when transmitted light is employed.

e. *Pigment in Birds.*

A n 11. A portion of the pigmentum nigrum of the eye of a Turkey, consisting of small narrow cells, which are arranged in masses somewhat of an arborescent figure, leaving between them more or less hexagonal spaces of various sizes. In some parts of the specimen it appears that the pigment was never present, as the masses of cells not only present a well-defined outline, but are collected together in groups of certain regular shapes, which resemble the stellate cells of fishes when very much magnified.

A n 12. A portion of the iris of the same Turkey, having a layer of stellate cells upon its inner surface; in many of the larger cells the nucleus may be

seen in the form of a small circular transparent spot occupying the centre.

A n 13. A portion of the iris of a Pheasant, *Phasianus Colchicus*, having its inner surface uppermost; the vessels have been injected, and are covered in many places with a layer of pigment cells of a peculiar stellate figure, which are most abundant on the pupillary margin.

A n 14. A portion of the pigmentum nigrum of the eye of a Fowl, *Phasianus Gallus*, which consists of a layer of small hexagonal cells full of very black pigment; in some few instances the white circular nucleus may be plainly seen.

f. *Pigment in Mammalia.*

A n 15. A portion of the pigmentum nigrum of the eye of a Porpoise, *Phocæna communis*, which consists of a layer of very minute hexagonal cells full of black granular pigment; in some few parts the transparent nucleus may be seen occupying the centre of the largest cells. A small cluster of the cells is shown in Plate IX. fig. 8; on an average they measure $\frac{1}{2000}$th of an inch in diameter.

A n 16. A portion of the pigmentum nigrum from the eye of a Sheep, *Ovis aries*, consisting of a layer of nearly equal-sized hexagonal cells full of granular pigment; in some cases the cell-wall is ruptured, and the granules have escaped; these when viewed with a power of 500 linear appear as minute more or less oval bodies, varying from $\frac{1}{10000}$th to $\frac{1}{15000}$th of an inch in diameter. Large transparent spots may be observed in many parts of the preparation, these are occasioned by the absence of one or more cells. The average diameter of the cells is $\frac{1}{1300}$th of an inch; a small cluster of them is represented in Plate IX. fig. 7.

A n 17. A portion of the choroid coat of the eye of a Sheep, which exhibits a layer of pigment cells of peculiar figure, especially at the end nearest the number. The cells are much elongated, most frequently spindle-shaped, but sometimes forked, as shown in Plate IX. fig. 14; in nearly every specimen the transparent central nucleus may be seen.

A n 18. A portion of the pigmentum nigrum from the eye of a human fœtus of six months; it consists of a layer of hexagonal cells, on an average $\frac{1}{1600}$th of an inch in diameter, each having a circular transparent nucleus in its centre, as shown at *a a* in Plate IX. figs. 10 and 11. The granules of pigment are of the usual size, but are not very abundant, so that when this specimen is viewed with the naked eye, it presents a brown rather than a black appearance.

A n 19. A portion of the pigmentum nigrum from the eye of an adult human subject, consisting of a layer of hexagonal cells on an average $\frac{1}{1000}$th of an inch in diameter, full of granules of very black pigment; in some few a trace of the nucleus is still visible; a part of this specimen is represented in Plate IX. fig. 9, and when compared with fig. 10, will serve to show the striking difference that exists in the structure of the same tissue in a fœtal and in an adult state.

A n 20. A portion of the pigmentum nigrum of the eye of a young Rabbit of black colour; it consists of a layer of cells of hexagonal figure, on an average $\frac{1}{1500}$th of an inch in diameter. Each cell is full of pigment granules, which in the mass present to the eye a jet black appearance.

A n 21. A similar preparation taken from the eye of a Rabbit of white colour, consisting of cells identical both in size and figure with those of the last described specimen, but differing from them in having a great diminution both in the quantity and colour of the pigment granules. The preceding preparation appears very black to the naked eye, but this one is of a light brown colour.

A n 22. A portion of cuticle from the arm of a Negro, having its inner or attached surface uppermost. The specimen appears to consist of two structures, one being of much darker colour than the other, and until lately described as a distinct layer under the name of *rete mucosum*. When viewed with a power of 100 diameters, this layer is found to be composed of a series of minute, more or less quadrangular cells, full of very black granules of pigment, which are arranged somewhat in a circular manner around the depressions for the reception of the

papillæ, as shown in Plate IX. fig. 12; when however a power of 600 diameters is employed, the cells will be found to resemble in shape those of the pigmentum nigrum of the choroid, as shown in Plate IX. fig. 13. If a vertical section of the same skin be examined, it may be seen that the darkest pigment is contained in the cells of the lowest layer, and as we proceed towards the free surface the colour becomes less and less dark; the cells containing the darkest pigment are more polygonal in figure than those at the free surface, which are flattened like scales, and hardly exhibit any colouring matter; it may however be proved that such scales when first formed were of the same nature as those in the lowest layer, but by pressure in growth have lost both their pigment and their original figure; therefore, that which has been described as a distinct structure under the name of *rete mucosum*, must be considered as being only the layer of cuticle last deposited.

A n 23. A portion of the cuticle of a Negro, which has been dried and mounted in Canada balsam; with a power of 40 diameters it exhibits a circular arrangement of the coloured cells, as shown in Plate IX. fig. 12; but with one of 250 each cell will be seen to be of a polygonal figure and full of black granular pigment, as shown in Plate IX. fig. 13. The cells are darkest and most numerous around the bases of the papillæ, a few only being shown in that part of the cuticle which invested their free surfaces.

A n 24. A vertical section of the skin of the face of an old woman, which exhibits the entire thickness both of cuticle and dermis; the lower or attached edge of the former may be seen to be distinctly coloured, but the free surface is white. The entire skin of the woman from whom this specimen was taken was remarkable for its brown colour.

A n 25. A vertical section of the skin of the face of a younger woman, including both dermis and cuticle; the latter is very nearly white throughout, the pigment in the last deposited layer of cells being almost, if not entirely wanting, the woman from whom this specimen was taken being of very fair complexion.

g. *Pigment in diseased Structures.*

A n 26. A portion of black pigment obtained from the skin of the face, immediately under the right eye of a young woman; it consists of cells somewhat like those of epithelium, all of which are more or less filled with granular pigment; the cells are lighter than the fluid in which they are mounted, they therefore rise to the surface. This peculiar pigment used to appear on the outer surface of the skin in the situation above described, and small portions of it might be brushed off with a Camel's hair pencil, but the colouring matter could not be destroyed by acids or by chlorine.

Presented by Peter Squire, Esq.

A n 27. A thin section of a melanotic tumour of the globe of the eye of a human subject, which consists of cells of irregular figure full of granules of very black pigment; many of the cells are ruptured and their contents have escaped, which will account for the immense numbers of minute black granules which occur in all parts of the preparation.

A n 28. A small portion of melanotic matter obtained from the ovary of a human female; it consists principally of minute pigmental granules of very dark colour, which have evidently escaped from cells, as their remains can not only be frequently observed, but in some parts perfect cells occur having similar granules in their interior. The shape of the cells varies considerably; sometimes they are round or oval, but the most common form is the elongated with both extremities pointed.

A n 29. A portion of black matter obtained from a lobule of the lung of a Calf; it consists of minute granules like those of pigment, which are deposited in the tissue of the lobule; sometimes they occur separately, but not unfrequently in the interior of small elongated cells, so firmly bound together as to be only separated with difficulty. The lung from which this specimen was taken, presented a very remarkable appearance; it was white and bloodless in all parts with the exception of about twenty of its lobules, which were perfectly black; these were not clustered together, but occurred singly, and in some instances were many inches apart. When cut into, a peculiar soot-like smell was given off, and the lobule appeared black throughout; it however still retained a portion of its cellular cha-

racter, the deposit not being of the same moist consistence as that of the melanotic tumours above described, but being in some cases so perfectly dry as not to soil the knife employed in dividing it.

Series VII.

Sclerous or Hard Tissues.

The solid framework forming the support of the digestive, locomotive and other systems of all animals is termed the *Skeleton.* It consists chiefly of earthy material separated from the food by certain vital processes of the animal, and deposited with wonderful regularity in a condensed albuminous or gelatinous matrix, which gives both firmness and solidity to the mass. In the lowest forms of animal life, as the Sponges, the earthy skeleton is composed of silica; in others higher in the scale, as the Mollusca, it consists of carbonate of lime; but in the Vertebrata it is formed principally of phosphate of lime, with a slight admixture of the carbonate. The skeleton may be composed either of one or many pieces, and may be either external or internal to the soft parts; in the former case new material is continually added to its circumference, or it may be periodically shed and formed anew; in these instances the skeleton has no inherent power of repair, but in the latter case, which is constant in the Vertebrata, it is supplied with vessels, and in the process of growth not only is there a deposition of new material, but an absorption of that which has become old and decayed; such skeletons also possess the means of self-reparation after injury or disease. The skeleton is not exclusively confined to animals; some of the Algæ or lowest form of vegetables, and grasses more especially, have a framework to their cells composed of silica, which is indestructible both by fire and mineral acids; but as it is still a matter of dispute whether some of the bodies classed as Algæ are not rather of an animal nature, it has been thought desirable not to describe their skeletons in this series, in which only those of a decidedly vegetable character will be included, but with the Infusoria, to which they are most nearly allied.

Subseries I. *Structure of the Skeleton of Vegetables.*

In the Histology of Vegetables, under the head of "Hard Tissues," a series of preparations, consisting principally of the stones of fruits, have already been described, in the cells of which may be traced a certain resemblance in structure to that of the bones of animals; in addition to this form of hard tissues, there exists in many plants, especially grasses, another kind composed of silica, which may without doubt be called the skeleton; it gives a firm basis of support not only to the cuticle, but to all the structures, such as hairs and scales that are sometimes developed from it.

It had been long known that after the combustion of a hay or corn-stack, masses of a species of glass formed by the union of silica with some of the salts of potash were to be found amongst the ashes, but it was reserved for our distinguished countryman Robert Brown, to point out that in the ashes themselves all the most delicate structures of the plants are not only preserved, but still retain the same order of arrangement as they did when the carbonaceous matters were present. The same subject has since been followed out with great care by an eminent microscopist, the Rev. J. B. Reade, without any knowledge of what had previously been done by Mr. Brown; and to both these gentlemen we are indebted for many valuable results. The silica exists principally in the cuticle, so that the skeleton may be termed *dermal*; it not unfrequently occurs in the cells situated in the interior of plants, and in one remarkable instance, viz. between the joints of the Bamboo, it is found in the form of nodulated masses of considerable size, known by the name of *tabasheer*. According to Mr. Reade*, silica is not the only material forming the skeleton of plants; both lime and potash also occasionally occur; the former being found in the calyx and pollen of the Mallow, and the latter in the petals of the Rose. Many persons have argued that all these earthy compounds are matters foreign to plants, having been accidentally introduced into them; but it is now generally considered that they are organized, and like resin, starch and gum, are produced by the organic power of vegetation.

A o 1. A portion of cuticle of *Equisetum hyemale*, known in commerce as "Dutch

* London and Edinburgh Phil. Mag., vol. xi. p. 416.

Rush"; it has been boiled in nitric acid, whereby all the carbonaceous matter has been removed, and nothing but the siliceous skeleton now remains; this consists of a series of elongated flattened cells with serrated margins, as shown in Plate X. fig. 1, having rows of stomata occurring at equal distances apart; these last are of an oval figure, and the opening in each is in the form of a slit, and the margins very much resemble a set of human teeth imbedded in the gums. The cells in the neighbourhood of the stomata are smaller than those occurring in other parts of the specimen, and are shaped so as to fill up all the irregular spaces occasioned by the stomata.

A o 2. A portion of the stem of *Equisetum hyemale*, which has been treated in a similar way to that of the preceding specimen. It exhibits both the stomata and cells of the cuticle like those above described, and in addition a few bundles of woody fibres surrounded by ordinary cellular tissue may be observed; the former may be readily known by their elongated shape and pointed extremities. This specimen unequivocally proves that the siliceous coating is not solely confined to the cells of the cuticle.

A o 3. A portion of a leaf of a Bamboo, *Bambusa minor*, after having been subjected to an intense heat in order to remove all matters not strictly entering into the formation of the skeleton. It consists of a series of prismatic cells with toothed edges, with rows of dark bodies about $\frac{1}{1000}$th of an inch in diameter, resembling in shape a section of a bi-concave lens, arranged at nearly equal distances apart. These bodies appear like the thickened fibres of the annular vessels found in the stem of *Equisetum fluviatile*, one of which is represented in Plate II. fig. 7 *b*, and the analogy is further supported by their being distinctly contained within the walls of a transparent tube, having in some cases a spiral vessel running parallel with it. In those parts of the specimen not saturated with balsam, the true shape of the interior of the cells may be well seen, the cavity being very much like a portion of one of the serrated fibres from the crystalline lens of fishes.

A o 4. A portion of the leaf of another species of Bamboo similarly treated by burning; it exhibits the cells of the cuticle and small cylindrical hairs

developed from some of them. Dark bodies, probably analogous to those described in the preceding specimen, are here present, but they differ from them both in number, shape, and regularity of arrangement; when viewed edgeways they are thin and narrow, but when one side is uppermost it is found to be slightly concave, and to have in some cases a dark granular spot either in the centre or near one edge. Their number appears nearly to equal that of the cells, but their arrangement is not in parallel rows as in the preceding specimen. Whether they are to be considered as masses of silica or as cups of a metallic oxide, as described in the cuticle of the stalk of wheat by Mr. Reade, cannot be well ascertained. A portion of this preparation is represented in Plate X. fig. 2: *a* is one of the cups wholly, and *b* another only partially decarbonized.

A o 5. A portion of the leaf of the same species of Bamboo, in which the carbonaceous matter has been only partially removed; the transparent portions exhibit the same appearances as those of the preceding specimen. Where the carbon is still present, numbers of small oval stomata may be plainly seen; but in the parts thoroughly decarbonized, only a faint indication of their presence can be observed.

A o 6. A portion of the stalk of Wheat after having been boiled in nitric acid; it consists of flattened elongated cells with deeply indented edges, occasionally interrupted by bands of narrow cells, having vessels and woody fibres mixed with them. Between these bands, and where the cells are largest, a few stomata arranged in parallel rows may be seen. The whole upper surface of the specimen is covered with projecting bodies called cups by Mr. Reade; these are chiefly of an oval shape, and have a dark body either in their centre or near one edge; they are most numerous over the bundles of woody fibres and vessels, and it would appear that their shape as well as their number is regulated by that of the cells, each cell having its cup, and where the cell is elongated, as seen in connection with the vascular bundles, there the cup is also most elongated. According to Mr. Reade, the cups are not soluble in caustic potash, nor are they acted on by a temperature sufficient to remove all carbonaceous matters; but when exposed to a very great heat in a platinum spoon, they

are fused, and leave upon the spoon a permanent light blue stain; hence he concludes that they consist of the oxides of metals. A portion of this preparation is represented in Plate X. fig. 4, and at *a* may be seen the remains of the fibre of a large spiral vessel, a circumstance of great interest, inasmuch as it proves that ultimate fibre as well as membrane may have silica intimately blended with it.

Presented by Mr. J. T. Norman.

A o 7. Three portions of the paleæ of an Oat, *Avena sativa*, two of which are in their natural state, and the third has been burnt. The former exhibit elongated cells with coarsely serrated margins, which last can be best seen in those cells that are filled with air. In each palea there are from eight to nine ribs, composed of an aggregation of thinner cells than those occurring in other parts, and on each side of the rib may be seen a row of oval stomata. On examining the burnt portion, which is the most transparent of the three, the cells of the ribs are plainly shown, and small cups, which were hardly visible in the above-described portions, are in this plainly brought into view.

A o 8. A portion of a palea of a Grass, *Festuca pratensis*, in its natural state; when examined with a power of 100 linear, it displays the serrated edges of the cells, and a large cup situated at one extremity of each; when the specimen is viewed as an opaque object, the cups can clearly be seen to project above the surface, and to have a thick rounded margin. A portion of this specimen is represented at *a* in Plate X. fig. 6.

A o 9. A portion of a palea of the same grass, which has been boiled in nitric acid; when viewed with a power of 500 diameters it displays the structure of the siliceous skeleton. The cells are short and flat, and provided with coarse serrated edges; nearly every cell has a large cup at one end; by the action of the acid a portion of the margin of each cup has been destroyed, but the depression in the centre, and the granular bodies at the bottom, are with this power very plainly displayed. Part of this specimen is represented at *b* in Plate X. fig. 6.

A o 10. A portion of the cuticle of a Dragon Cane, after having been boiled in

nitric acid; it consists of more or less hexagonal thick-walled cells of various sizes, having numerous granules of silica not only entering into the substance of the walls of the cells, but projecting in the shape of small angular facets into what may be called their cavities. A portion of this specimen is represented in Plate X. fig. 3.

Presented by the Rev. James Landy Brown.

A o 11. A portion of the cuticle of the same cane, which was boiled in nitric acid before being mounted in Canada balsam; it exhibits appearances similar to the preceding specimen, but the greater part of the silica is very opaque, and the facets projecting into the interior of the cells are not so well shown as in the specimen mounted in fluid.

Presented by the Rev. James Landy Brown.

A o 12. A portion of the cuticle of a Malacca Cane, which, like the preceding specimen, has been boiled in nitric acid; it consists of small hexagonal thick-walled cells about $\frac{1}{1300}$th of an inch in diameter, which are full of granules of silica. A portion of this specimen is represented in Plate X. fig. 9, and both this and the preceding have become so exceedingly brittle from the loss of their carbonaceous matter, that the cells will hardly hold together. *Presented by the Rev. James Landy Brown.*

A o 13. A portion of the cuticle of the same cane, which was treated with nitric acid before being mounted in Canada balsam; it exhibits a similar structure to that of the preceding specimen, but with this difference; where the parts were lightest in that specimen, they are darkest in this. On the edges may be noticed some cells without any granular matter; these belong to the first layer of tissue underneath the cuticle, and have no silica in their interior, but only in their walls.

Presented by the Rev. James Landy Brown.

A o 14. A portion of the cuticle of a Manilla Cane, which has been treated with nitric acid in the same way as the two preceding specimens; it consists of cells of unequal size, but generally of hexagonal figure, each having a small central cavity; the walls are thick, and the silica is principally deposited in a homogeneous form. On examining some of the edges of

this specimen, a few thin-walled cells without any central cavity may be seen; these belong to a layer of ordinary cellular tissue found beneath the cuticle. A part of this preparation is represented in Plate X. fig. 8.

Presented by the Rev. James Landy Brown.

A o 15. A portion of the cuticle of the same cane, which, after being treated with nitric acid, has been mounted in Canada balsam; it exhibits rather more plainly than the preceding specimen the structure of the cells and the granules of silica. *Presented by the Rev. James Landy Brown.*

A o 16. Portions of the cuticle of the Rattan Cane after having been treated with nitric acid; it consists of minute thick-walled hexagonal cells, entirely filled with silica, except a small cavity in the centre, which is of a light colour and is provided with a nucleus. On the edges of the specimen, and in some cases detached from them, may be seen a thin layer of transparent cells of larger size and different shape to those of the cuticle: these belong to the cellular tissue over which the cuticle is laid.

Presented by the Rev. James Landy Brown.

A o 17. A portion of the cuticle of a Wanghae Cane, which has been boiled in nitric acid, and consists of a series of very minute oblong cells full of granules of silica; projecting from the upper surface may be noticed a few short cylindrical hairs, the cell-walls of which are likewise composed of silica. In some parts there is a trace of cups like those in the Oat and Wheat. *Presented by the Rev. James Landy Brown.*

A o 18. A portion of the cuticle of a Grass, *Pharus cristatus*, having ribs composed of little masses of silex of peculiar figure, and most probably of the same nature as those described in Preparation A o 3, as existing in the leaf of the Bamboo. When viewed *in situ*, each mass is in shape somewhat like an hour-glass, and the entire series is arranged close together in longitudinal rows which appear double, one row being situated on the upper, and the other on the under surface; on examining those edges of the specimen which are opposite either to the number or the name, the ribs will be found to extend beyond the cuticular cells, and the shape of the little masses above described can in these situations be well made out.

The membrane between the ribs is composed of small cells with serrated edges, and their upper surface is covered with siliceous stellate bodies resembling some forms of raphides. A portion of this preparation is represented in Plate X. fig. 5 ; at *a* are shown the masses arranged in linear series, and at *b* the stellate bodies.

A o 19. A small portion of the same cuticle after having been boiled in nitric acid ; it exhibits very plainly the shape of the cells and their serrated edges, but the stellate bodies and those forming the ribs are in great part displaced, from the destruction of the carbonaceous matter which held them together. The entire surface of the cuticle is now seen to be covered with minute oval bodies, having a central spot like a nucleus ; the whole of the circumference cannot be seen in every specimen, but only in those that are flat. If the parts where the ribs were situated be examined, a transparent spot corresponding to each of the hour-glass shaped masses may be noticed, and between each spot there is a portion of the cuticle covered with granules, which is also of the same shape as the transparent spot. It would appear that the former was the situation occupied by the mass of flint, and that the latter was the space between each mass. In addition to these granules, numerous small stomata may be seen, and an abundance of cup-shaped bodies with granules arranged around them.

A o 20. A portion of the cuticle from the under surface of the leaf of *Deutzia scabra*, after boiling in nitric acid ; in addition to the remains of stomata and ordinary cellular tissue, it exhibits the siliceous skeletons of stellate hairs of remarkable beauty, arranged without any regular order upon the free surface of the cuticle ; some of these hairs are represented in Plate X. fig. 7 : all of them, as there shown, have little tubercles projecting from their arms. A few fragments of spiral vessels may be seen at one end of the specimen, proving that the ultimate fibre as well as the cellular tissue is coated with silica. *Presented by Mr. J. T. Norman.*

A o 21. A portion of the cuticle of the petal of a Mallow, *Malva sylvestris*, the upper surface of which is thickly studded with stellate masses of crystals, said to be of carbonate of lime ; they much resemble the raphides of the

oxalate, which are found in abundance in the cells of the Rhubarb and many other plants. From the preparation having been mounted in Canada balsam, it is difficult at first sight to say whether the crystals are on the external surface of the cuticle, or in the interior of cells; in those parts of the specimen in which only a few of the crystalline masses occur, the cell-walls may be distinctly seen, but in all others they are hidden by the close approximation of the masses themselves.

The above-described preparation has been introduced merely to show that these masses of crystals, which resemble raphides, ought not to be considered as forming the skeleton of this part of the plant; for if the petal were subjected to heat or acid, very little trace of either cells or crystals would remain.

Subseries II. *Skeleton of Animals.*

Sponges.

Sponges, according to Dr. Johnston*, are "organized bodies growing in a variety of forms, permanently rooted, unmoving and unirritable, fleshy, fibro-reticular, or irregularly cellular, elastic and bibulous, composed of a fibro-corneous axis or skeleton, often interwoven with siliceous or calcareous spicula, and containing an organic gelatine in the interstices and interior canals; they are reproduced by gelatinous granules called *gemmules*, which are generated in the interior, but in no special organ. All are aquatic, and with few exceptions marine."

The skeleton, which is the only part of the sponge here to be described, is composed principally of two kinds of material, the one animal, the other mineral; the first of a fibrous horny nature, the second either siliceous or calcareous. The fibrous portion consists of a network of smooth and more or less cylindrical threads of a light yellow colour, and with few exceptions always solid; they frequently anastomose and vary considerably in size; when developed to a great extent, as shown in Plate X. fig. 10 *a*, needle-shaped siliceous bodies termed *spicula* are found in their interior; in a few cases only one of these spicula is met with, but most commonly they occur in bundles. In some sponges, as

* British Sponges and Lithophytes, p. 78.

those belonging to the genus *Halichondria*, the same horny kind of material is present in greater or less abundance, but its fibrous structure has become obscure; the fibres however in these cases are represented by siliceous needle-shaped spicula, and the horny matter serves the important office of binding them firmly together, as shown in Plate XI. fig. 1; there is however one remarkable exception to this rule, viz. *Dictyochalix pumiceus**, described by Mr. S. Stutchbury, in which the fibrous skeleton is composed of threads of silex quite as transparent as glass; portions of this singular sponge form Preparations A p 10, 90 and 91.

The mineral portion, as before stated, consists of spicula composed either of silica or carbonate of lime; the first kind is the most common and likewise most variable in shape, and presents every gradation in form from the acuate or needle-shaped, as shown in Plate XI. fig. 2, to that of a star, represented in figs. 12, 13. The calcareous spicula, on the contrary, are more simple in their form, being principally acicular, but not unfrequently branched or even tri- or quadriradiate; the two kinds, the siliceous and calcareous, according to Dr. Johnston, not having hitherto been detected coexistent in any native sponges.

The spicula exhibit a more or less distinct trace of a central cavity or canal, the extremities of which are closed or hermetically sealed; in their natural situation they are invested by an animal membrane, which is not confined to their external surface; but in many of the larger kinds, as pointed out by Mr. Bowerbank, its presence may be detected in their central cavity, by exposing them for a short time to a red heat, when the animal matter will become carbonized and appear as a black line in their interior.

Many authors have described the spicula as being crystalline and of an angular figure, and have considered them analogous to the *raphides* in plants, but it requires no great magnifying power to prove that they are always round, and according to their size are made up of one or more concentric layers, as shown in Plate X. fig. 12 *e*. The spicula occupy certain definite situations in sponges; some are peculiar to the crust, others to the flesh, others to the margins of the large canals, others to the fibrous network of the skeleton, and others belong exclusively to the gemmules. Thus for instance in *Pachymatisma Johnstonia*, according to Mr. Bowerbank, the spicules of the crust are simple, minute and fusiform, having their surfaces irregularly tuberculated, and their terminations

* *Iphiteon* of the French Museum.

very obtuse, whilst those of the flesh are of a stellate form, the rays varying in number from three to ten or twelve.

Silica however may be found in one or more species of sponge of the genus *Dysidea*, not only in the form of spicula, but as grains of sand of irregular shape and size, evidently of extraneous origin, but so firmly surrounded by horny matter as to form, with a few short and slightly curved spicula, the fibrous skeleton of the animal. In these sponges the spicula are of large size, and are disposed in lines parallel with the masses of sand.

Spicula are not exclusively confined to the body of sponges, but occasionally form the skeleton of the gemmules, and may be situated either on the external or internal surface of these bodies. A good example of the former kind occurs in the common freshwater sponge *Spongilla fluviatilis*, represented in Plate XI. fig. 19, and one of the latter, which is the most common situation, is shown in fig. 10; in these instances the spicula are of very minute size, and are disposed in lines radiating from the centre to the circumference, the markings on the outer surface of the gemmule being the ends of the individual spicula. In all the young gemmules the spicula project from the outer margin as so many spines, but in process of growth the spines become more and more blunt, until at last they appear as so many angular tubercles.

a. *Skeleton of Sponges consisting of Horn.*

A p 1. A portion of the skeleton of a Sponge from the West Indies, probably of the genus *Verongia*; it is composed of a network of cylindrical horny anastomosing fibres of a yellow colour; all having a cavity running through their centre, and like the fibres themselves forming a continuous network. A portion of this specimen is represented in Plate X. fig. 11 *c*.

A p 2. A portion of the skeleton of another Sponge of the same genus, having a coarser horny network than the preceding specimen, but like it being composed of horny fibres having a central cavity.

A p 3. A portion of the horny skeleton of a Sponge from the West Indies, known as the *Spongia officinalis* of Lamarck; it consists of a series of large amber-coloured fibres arranged in the form of a network. The fibres are solid cylinders, and not tubular as those of the preceding specimen.

A p 4. A portion of the horny skeleton of a Sponge from the Mediterranean, being another variety of *Spongia officinalis*, and known in commerce as Turkey sponge. It consists of a network of much finer fibres than those of the preceding specimen; they are also solid, and independent of being of smaller size, are likewise much lighter in colour. A portion of this sponge is represented in Plate X. fig. 10 *d*.

A p 5. Portions of the skeleton of a horny Sponge remarkable for the size of its fibres, and for the presence of a network of small fibres between the meshes formed by the larger ones. The fibres, like those in Preparations A p 1 and 2, are hollow, and the specimen from which the preparation was taken resembles to a very great extent a magnified portion of injected human lung having its air-cells distended.

b. *Skeleton composed of Horn in which Spicula are imbedded.*

A p 6. A portion of the horny skeleton of a Sponge allied to the genus *Verongia*, having a coarse network of large fibres, in many of which may be discerned either a single large spiculum, or others of smaller size arranged in bundles, as shown in Plate X. fig. 10 *a*. The spicula are not present in every fibre, but principally in those that are of large size, and more or less flattened. *Presented by Mr. C. Poulton.*

A p 7. A portion of the ordinary Turkey Sponge of commerce, exhibiting a network of fibres of small size; the majority of the fibres are solid, but occasionally larger specimens may be seen, in which either a single large specimen or a bundle of smaller ones occur.

c. *Sponges having a skeleton of Spicula and gelatinous horny matter.*

A p 8. A portion of the skeleton of a Sponge, *Halichondria simulans*, consisting of a framework of siliceous needle-shaped spicula, kept together by a soft kind of horny material. The spicula are arranged in bundles, and are in some parts so thickly coated with the horny matter that they cannot well be seen. A portion of this preparation is represented in Plate XI. fig. 1.

A p 9. A portion of the skeleton of another species of *Halichondria*, which has been dried and afterwards mounted in Canada balsam; the spicula are

retained *in situ* by the animal matter, but this last has been rendered so transparent by the balsam as to be almost invisible. Plate XI. fig. 2.

d. *Sponges having a fibrous Skeleton of Silica.*

A p 10. A portion of a Sponge, *Dictyochalix pumiceus*, having a fibrous skeleton formed entirely of silex, so transparent as to present an appearance of being composed of spun glass.

Presented by J. S. Bowerbank, Esq., F.R.S.

e. *Siliceous Spicula pointed at both extremities—Acerate*.*

A p 11. Spicula of a species of *Halichondria* separated from the animal matter by means of boiling nitric acid. They consist principally of two kinds, one straight, the other slightly curved; both have pointed extremities, and are known as the acerate variety. A few of these spicula are represented in Plate XI. fig. 3.

A p 12. Spicula of *Spongilla fluviatilis*; they are of three principal kinds, all with few exceptions having pointed extremities. The first and most common kind is by far the largest, and is slightly curved; the second is smaller and straight; whilst the third is still smaller and is covered with very minute spiny projections. In various parts of the specimen may be seen the skeletons of *Naviculæ*, *Gallionellæ* and other siliceous Infusoria, together with a few examples of the spicula belonging to the gemmules of the same sponge; these may be known by their peculiar figure, which is not unlike that of an axle having a wheel at each end, as shown in Plate XI. figs. 20, 21.

A p 13. Spicula of *Spongilla lacustris*, which differ but little in shape from those of the preceding specimen; the largest are curved and pointed at both ends, the next size is straight, but the tuberculated form is short and curved also.

A p. 14. Spicula of a Sponge of the genus *Halichondria*, the greater part of which are slightly curved, and all provided with pointed extremities; these, like the preceding specimens, belong to the acerate variety.

* The terms employed to distinguish the different forms of spicula, have in all cases been derived from manuscript notes by Mr. Bowerbank, now nearly ready for publication.

A p 15. Spicula of a Sponge, likewise of the genus *Halichondria*; all are acerate, having pointed extremities, but many of them are remarkable for their extreme delicacy.

A p. 16. Spicula of a Sponge of the genus *Halichondria*; they belong to the acerate variety, are pointed at both ends, and remarkable for being nearly all of equal size, although some few are slightly curved.

A p 17. Spicula obtained from a Sponge of the genus *Tethea*; they are pointed at both extremities and are remarkable for their large size; in the same specimen may be observed others of great length, but of very small diameter, being pointed at one end and provided with three or more hooks at the other: these will be again alluded to. The skeleton of the Sponge from which this preparation was taken was very remarkable: the spicula, being of great length, were so interwoven with each other as to form oval masses half an inch or more in diameter, which could be handled without separating the individual spicula.

f. *Spicula round at one end and pointed at the other—Acuate.*

A p 18. Spicula of a Sponge, probably of the genus *Halichondria*, exhibiting two or three varieties of form, the only one here requiring mention being the largest; these it will be seen are pointed at one end and rounded at the other, as shown at *a* in Plate XI. fig. 4.

A p 19. Spicula of a Sponge of the genus *Halichondria* from New Zealand; they are of small diameter and of various forms; the only one here requiring notice is the largest, which is provided with a point at one end and is rounded at the other.

A p 20. Spicula obtained from a Sponge of the genus *Tethea*; they are of three kinds, two being stellate and the other of large size, rounded at one extremity and pointed at the opposite. The last form has this peculiarity, each specimen is largest in the middle and tapers slowly towards both ends, the rounded one being about one-third less in diameter than the middle portion of the spiculum.

g. *Spicula round at one end pointed at the other, the former being dilated into a knob—Spinulate.*

A p 21. Spicula of a Sponge from New Zealand, probably of the genus *Hali-*

chondria, all the large specimens of which are pointed at one extremity, whilst the other is dilated into a slight knob, like that forming the head of a pin, shown at *c* in Plate XI. fig. 4; in this specimen there are smaller spicula of the same character, but having in addition spinous surfaces, as shown at *b* in fig. 4.

A p 22. Spicula from a Sponge, probably of the genus *Dysidea*; they are few in number and of large size, being pointed at one end, whilst the other is dilated into a round knob. The specimen is remarkable for the large quantity of silica occurring with the spicula, this being employed with them in the formation of the framework of the skeleton, and in many instances supplying their place. The presence of the silica will no doubt explain why so small a number of the pin-shaped spicula are to be found in this sponge.

A p 23. Spicula of a Sponge of the genus *Halichondria*, all of which are remarkable for their great resemblance to pins.

A p 24. Spicula obtained from a Sponge attached to a coral found at Ceylon; they are of various forms, but only two require especial mention in this place, one being of the shape of an ordinary pin, the other much shorter and broader, having a knob at one extremity, whilst the other is partly rounded, and from its very centre a minute point projects, as shown at *h* in Plate XI. fig. 9. *Presented by Mr. J. W. Bond.*

h. *Spicula having both extremities rounded—Cylindrical.*

A p 25. Spicula obtained from the same Sponge as those described in Preparation A p 18; all the smaller kinds are of cylindrical figure, quite straight and having both ends rounded; a pin-shaped specimen is now and then to be seen.

A p 26. Spicula obtained from a Sponge found in the South Seas, many of which are not only rounded at both extremities, but these parts are much larger in proportion than the middle, so that a spiculum of this form might be called bi-spinulate, as shown in Plate XI. fig. 9 *a*; some of them are slightly curved, others quite straight.

A p 27. Spicula obtained from another Sponge of the genus *Halichondria*, from

the South Seas; amongst many other peculiar forms may be noticed some few having both extremities dilated like the head of a pin, to which the name bi-spinulate might be given; they are all straight, and of larger size than those in the preceding specimen.

Presented by G. Shadbolt, Esq.

i. *Spicula of the acerate form covered with spines.*

A p 28. Spicula obtained from *Spongilla fluviatilis*; they are of three kinds, but the only one here requiring mention is the smallest; it is pointed at both ends and is covered with very minute spines.

A p 29. Spicula obtained from *Spongilla lacustris*, which, like those of the preceding specimen, are of three kinds, but the smallest is the only one that comes under the above-defined class; it is pointed at both extremities and covered with minute spines: this form of spiculum however is shorter and more curved than that in the *S. fluviatilis*.

A p 30. Spicula obtained from a Sponge of unknown genus, which present many varieties of form, but the one belonging to this division is short, somewhat cylindrical in figure and pointed at both extremities; the outer surface is covered with spines arranged in an annular form. There are three or four of such spicula in this preparation, and all agree in having both extremities pointed. Plate X. fig. 12 *b*.

k. *Spicula of the acerate form covered with tubercles.*

A p 31. Spicula from a Sponge of unknown genus, exhibiting many curious forms; within the circle may be seen one spiculum of remarkable beauty, being of large size, rounded at both ends and slightly bent; its outer surface is covered with rows of tubercles of circular figure, which project some little distance beyond the free margin: this spiculum is represented at *c* in Plate X. fig. 12. In this preparation may also be seen fragments of similar spicula, together with gemmules of two kinds, which will be described hereafter.

l. *Spicula of the acuate form covered with spines.*

A p 32. Spicula obtained from a Sponge of the genus *Halichondria*, found in New Zealand; they are of small size, blunt at one end, and taper gradu-

ally to a point at the other; from their free surfaces a few small spines project, these are arranged without any regular order, and are most numerous about the middle of the spiculum. Many other kinds of spicula are present, but none of them belong to this series; a few of the above-described specimens are represented at *b b* in Plate XI. fig. 4.

A p 33. Spicula of a Sponge of unknown genus from the South Seas, which, like the preceding, are of the acuate form and provided with spines, but not in very great abundance; they are arranged in alternate rows, and are largest and most numerous around the base of each spiculum; a few of the most characteristic specimens are represented in Plate XI. fig. 5.

A p 34. Spicula of a Sponge of unknown genus, having their outer surfaces covered with spines arranged in an annular form; some of the spicula are straight, others are slightly bent, either in the middle or near the base, as shown at *a a* in Plate XI. fig. 6. The spinous form of spiculum was very abundant in this specimen; other varieties, such as those represented at *b* and *c*, were only occasionally to be met with, and might almost be considered as foreign to this species of sponge.

A p 35. Spicula of a species of Sponge, probably of the same genus as that from which the preceding specimens were taken; they however differ from them in one or two points, being always more or less conical, and having their spines arranged in rings, the number of rings in a single spiculum being nearly double that in one of the preceding; some of the most striking examples of this peculiar form are represented at *b b* in Plate XI. fig. 7.

A p 36. Spicula of a Sponge of unknown genus from Algoa Bay; they are of the form termed clavate, and are covered with short stout spines, a group of them being represented at *c c* in Plate XI. fig. 7. In the same specimen may be seen the curved spinulate form of spiculum shown at *a a* in fig. 7.

m. *Spicula, sharp at one extremity and expanding into two points at the other—Expando-binate.*

A p 37. Spicula obtained from a Sponge of the genus *Pachymatisma*, consisting

principally of the expando-binate form, that is, sharp at one end and expanded into two points at the other, as shown in Plate XI. fig. 9 *d*; these spicula are of large size, and occur in great abundance; they serve to connect the crust and the fleshy matter of the sponge firmly together.

n. *Spicula, sharp at one end and expanding into three points at the other—Expando-ternate.*

A p 38. Spicula obtained from a Sponge, *Pachymatisma Johnstonia*; they are of large size, pointed at one end, and expanding into three large branches at the opposite, none of them being in the line of the body, but arranged at angles of 45° to it. These spicula, like the preceding, connect the crust and the fleshy matter of the sponge firmly together; one of them is represented in Plate XI. fig. 9 *c*.

A p 39. Spicula obtained from another specimen of *Pachymatisma Johnstonia*; like the preceding they are of large size, sharp at one extremity and expanding into three points at the other; on account of the thickness of this part, only a few of the spicula have all three points perfect.

A p 40. Spicula obtained from a Sponge, *Tethea lyncurium*; they are of three kinds; one exceedingly slender with recurved hooks; another of larger size and pointed at both extremities; whilst the third, which is the smallest and least common, belongs to the expando-ternate variety, having the three points all arranged at an angle of 15° to the body of the spiculum.

o. *Spicula of the Dichotomo-expando-ternate variety.*

A p 41. Spicula of *Pachymatisma Johnstonia*, amongst which may be seen a few of remarkable form; the only one here requiring mention is sharp at one extremity and expanding into three branches at the other, each of which again divides into two, or in other words, terminates dichotomously. One of these spicula is shown at *e* in Plate XI. fig. 9.

A p 42. Spicula from a Sponge of a species of *Pachymatisma*, amongst which may be seen a few specimens of the peculiar form described in the last preparation; the dichotomous termination of the three branches is well shown.

p. *Spicula in which the branches are recurved—Recurvo-binate, ternate, &c.*

A p 43. Spicula obtained from a Sponge, *Tethea lyncurium*, all the very slender forms of which have their terminal branches recurved; in a few specimens there are only two, in most of the others there are four short branches or hooks. These spicula are of small diameter and great length, and are found nearer the centre of the sponge than the large acerate specimens, their hooked extremities being lodged in the crust, which they serve to secure firmly to the soft central fleshy portion.

A p 44. Spicula obtained from a species of *Pachymatisma*; they present several varieties of form, but the only one here requiring notice is the recurvo-ternate, a specimen of which is represented at *f* in Plate XI. fig. 9. This kind of spiculum is analogous to that described in the preceding preparation, and like it is remarkable for its length, and for its uniformly small diameter.

A p 45. Spicula obtained from the same Sponge as Preparation A p 22, amongst which may be noticed one very peculiar specimen; this is of small size, rounded at one extremity, and having six or more short hooks at the other; a representation of it is given at *f* in Plate X. fig. 11, as seen under a magnifying power of 250 diameters.

q. *Spicula having hooks at both extremities—Bi-recurvo-ternate.*

A p 46. Spicula obtained from a Sponge, probably of the genus *Tethea*, some of which are of the stellate, others of the spinulate, and some few of the branched variety; but the form here requiring especial attention is of small size, much elongated, and provided with hooks at both extremities; those situated at the part, which for the sake of distinction may be called the apex, are of smaller size and fewer in number than those at the base; the shaft also is slightly spinous. One of these spicula is represented at *b* in Plate XI. fig. 9; the comparative size of the shaft and hooks is correctly given, but the former is considerably reduced in length.

Presented by J. Hilton, Esq.

A p 47. Spicula from the same Sponge, amongst which may be noticed several specimens of the peculiar form described in the preceding preparation;

they may generally be seen in the neighbourhood of the parts in which the other forms of spicula are closely collected together in small groups.

Presented by J. Hilton, Esq.

r. *Radiated Spicula—Tri-radiate.*

A p 48. Spicula obtained from a Sponge of the genus *Grantia*; they are of the tri-radiate form, and are composed of carbonate of lime; in some instances the three rays are of equal length, but most commonly one is a little longer than the others. Two of these spicula are represented at *c c* in Plate XI. fig. 8, under a power of 40 diameters.

A p 49. Spicula and gemmules obtained from a Sponge of the genus *Geodia*; amongst other varieties may be noticed a tri-radiate specimen of large size, represented at *b* in Plate XI. fig. 8; the rays exhibit no trace of a cavity, and from the circular marking in the centre, there is reason to suppose that either a fourth ray or a shaft was attached to it in its perfect condition.

A p 50. Spicula obtained from a Sponge found in the Levant, amongst which may be noticed the large tri-radiate specimen represented at *a* in Plate XI. fig. 8; this is of much larger size than the preceding specimen, and exhibits the central communicating cavities very plainly.

A p 51. Spicula from the residue of a Levant Sponge; they are of many kinds, but the only one here requiring notice is of the tri-radiate form, each ray being short and broad, and provided with a cavity; all three of these communicate by means of a dilated receptacle in the centre or point of junction of the rays. This specimen is represented at *a'* in Plate XI. fig. 8.

s. *Radiated Spicula—Quadri-radiate.*

A p 52. Spicula obtained from the residue of a Sponge from Smyrna, amongst which may be seen one of the quadri-radiate form; this, however, unlike that described in Preparation A p 49, does not appear to have had in its perfect state another ray or a shaft connected to it, but the rays are slightly curved, and not all on one plane as in the tri-radiate specimens.

Presented by Mr. J. T. Norman.

A p 53. Spicula of Sponge obtained from a species of *Geodia*; they present many of the radiated forms, but those having three, four, or six rays, are most abundant; one with four is represented at *d* in Plate XI. fig. 8.

t. *Multi-radiate Spicula.*

A p 54. Spicula of a Sponge, *Pachymatisma Johnstonia*, having a large number of gemmules mixed with them; those requiring notice in this place are of the multi-radiate form, that is, having from five to ten rays each; all exceeding the latter number belong to the stellate variety presently to be described. Eight of these spicula are represented in Plate XI. fig. 8; they have been selected in order to show that examples may be found in which the rays increase in numerical succession.

A p 55. Spicula from a Sponge of the genus *Geodia*, amongst which may be noticed many examples of the multi-radiate form, having the number of their rays varying from three to ten or more, so that a transitional series may be readily seen from the tri-radiate to the stellate variety; and it would appear that the latter was the perfect condition, and that the others were in different stages of development.

u. *Stellate Spicula.*

A p 56. Spicula obtained from a Sponge, *Tethea lyncurium*, all of which are of the sphero-stellate variety, that is, consisting of a central spherical body from which short conical spines or rays project, as shown at *a* in Plate XI. fig. 12, when magnified 100 diameters, or at *b* under a power of 250.

Presented by J. S. Bowerbank, Esq., F.R.S.

A p 57. Spicula obtained from another species of *Tethea* from the Navigators' Islands; they differ from those of the preceding specimen in being smaller, and in having the rays longer and thinner. These spicula vary much in size; the smallest forms have their rays longer in proportion than the largest, but these last exhibit the central part or body most distinctly. A few small multi-radiate specimens may occasionally be seen; these also have a spherical centre from which the radii are given off. Eight specimens of these stellate spicula are represented in Plate XI. fig. 13; when these are compared with that shown at *b* in fig. 12, the difference is very striking. *Presented by Capt. Sir E. Home, Bart., R.N.*

A p 58. A similar specimen, in which the large stellate spicula are not so abundant as in the preceding preparation, but the acerate, spinulate and small stellate forms are more numerous. The latter, it will be noticed, have very slender arms of uniform diameter, radiating from a small central spherical body. *Presented by Capt. Sir E. Home, Bart., R.N.*

A p 59. Spicula obtained from another species of *Tethea*; they are of the stellate form, and in all other respects, except in size, resemble those described in Preparation A p 56. In all parts of the specimen may be noticed other spicula, either of the multi-radiate or stellate variety; they are very minute, and consist of a central body, from which radiate a considerable number either of round or flattened arms, each one of which is slightly expanded at its free extremity.

A p 60. Spicula obtained from another specimen of *Tethea*, but most probably of the same species as the last preparation; the large stellate forms, as well as the smaller ones, are precisely similar to those above described, and the latter also present the constant character of having the free extremities of all their rays more or less expanded.

A p 61. Spicula obtained from a Sponge, probably of the genus *Geodia*, which are remarkable not only for their minuteness, but for having each ray of the star expanding and terminating in three or more short spines; other stellate spicula are present, but none of them differ from the forms already described. *Presented by Mr. J. T. Norman.*

A p 62. Spicula from the same Sponge, but occurring in much greater numbers; in this case they are mixed with many of the straight forms, such as the acuate, acerate and spinulate, some of which are covered with spines; a few gemmules like those of *Geodia* are also occasionally to be met with.
Presented by Mr. J. T. Norman.

v. *Branched Spicula.*

A p 63. Spicula obtained from a Sponge attached to a Coral dredged up at Ceylon; they are remarkable for the variety of their forms, some of which have already been described in Preparation A p 24; those how-

ever here requiring mention are more or less branched; of these, the simplest forms are the tri-radiate with dichotomous extremities; others are quadri-radiate, each ray terminating dichotomously; others are tri- and quadri-radiate, each ray being of the ternate variety; and lastly, some few may be seen in which one or other of these characters may be repeated from six to twelve times, so that a hexagonal network is formed by the union of the branches in the centre.

A p 64. Spicula obtained from the same Sponge, which in addition to the forms above described, also exhibit others that are branched, and at the same time covered with spines; it would however appear from many fragments of a similar spinous character mixed up with the spicula, that this variety, although much resembling certain of the branched spicula, might have belonged to a sponge having a fibrous skeleton of silica, such as the *Dictyochalix pumiceus* described in Preparation A p 10; these specimens however are much thinner and more transparent than those of the latter sponge. *Presented by Mr. J. W. Bond.*

A p 65. Spicula taken from the same Sponge as Preparations A p 46, 47; amongst them may be seen many belonging to the present series; the most common forms being those having three or four branches, each of which has a bi- or tri-furcate termination. *Presented by J. Hilton, Esq.*

A p 66. Spicula obtained from a Sponge of unknown genus, belonging to the double bi-ternate variety, that is, consisting of a central portion or shaft, from both ends of which three branches are given off, each of which again divides into three, or has a tri-furcate termination, so that a single spiculum has no less than eighteen pointed extremities. Two specimens of this remarkable variety are represented in Plate XI. fig. 11.

Presented by H. Hopley White, Esq.

w. *Spicula more or less curved—Curvate.*

A p 67. Spicula obtained from a Sponge attached to a coral from Ceylon. Amongst many curious forms in which this preparation abounds, may be noticed a few specimens of uniform diameter throughout, but all of which are more or less curved; in some cases the curve is single, in others two

or more may be found in the same spiculum, as shown at *d* in Plate X. fig. 12. Many very curious varieties may be found in some of the other preparations, as for instance A p 46, 47 and 65.

x. *Spicula having both extremities bent alike—Bi-curvate.*

A p 68. Spicula obtained from a Sponge, probably of the genus *Geodia*, found at Trieste. The principal forms are the multi-radiate and stellate, but a few specimens may be seen of the bi-curvate variety, represented at *f* in Plate X. fig. 12. One of these, from which the drawing was made, is situated within the ring marked on the upper glass with paint.

Presented by Mr. J. T. Norman.

y. *Spicula twice bent and having extremities like the flukes of an anchor, bi-curvate anchorate.*

A p 69. Spicula of a Sponge from the South Seas; amongst them may be found some very small specimens twice bent, and having their extremities expanded somewhat like the flukes of an anchor, but in the present instance each fluke has a tricuspid termination. Seven of these spicula in various positions are represented in Plate XI. fig. 15.

Presented by G. Shadbolt, Esq.

z. *Spicula not capable of being included in any of the preceding classes.*

A p 70. Spicula obtained from a Sponge, probably of the genus *Geodia*, amongst which may be seen one very curious specimen; it consists of a cylindrical shaft of uniform diameter, as shown at *e* in Plate X. fig. 11, having at one extremity a series of projections which appear like a stellate body composed of four oval rays resembling the petals of a flower, and at the other two of such star-like projections intimately blended together. The central cavity is well shown, and as it is continued to the very end, even beyond the projections in the extremity first described, it would appear that the spiculum is not perfect, and that some portion has been broken off. Fragments of other spicula of the same kind are also occasionally to be met with in this preparation, as well as a few instances of some of the acerate forms having a small branch given off at an angle from their sides, each branch having a central cavity communicating with that of the parent spiculum.

A p 71. A spiculum of peculiar form obtained from a Sponge, probably of the genus *Geodia*; it belongs to the tri-radiate variety, and its outer surface evidently appears to have been covered with minute spines arranged in an annular form, but the annuli now only remain as rough elevations from the surface. The specimen is represented at *a* in Plate X. fig. 12, and it will be seen that the ends of two of the rays have been broken off.

A p 72. Spicula obtained from a small oval Sponge, about an inch in length by half an inch in breadth; they are of two kinds, one of the anchorate form described in Preparation A p 69, the other of the acuate, and remarkable for its peculiar proportions, its diameter at the base being $\frac{1}{650}$th of an inch, whilst its length is only $\frac{1}{50}$th of the same quantity.

Gemmules.

The seed-like bodies found in the interior of some sponges, as before stated, are termed *gemmules*; they are occasionally provided with a skeleton composed of a series of very minute siliceous spicula, arranged in a more or less compact radiated form, and having in their fully developed state a pore or funnel-shaped opening leading into their interior. In the early stages of growth, as shown at *c*, *d* and *i* in Plate XI. fig. 10, the spicula project from the free surface in the form of spines; but in full-grown specimens, as shown at *b* and *g* in the same figure, their free extremities are more or less angular and blunt. In some of the freshwater sponges, as shown in Plate XI. fig. 19, the gemmules are of large size, and spicula of a bi-rotulate form give a firm coating to their external surface. The internal part of these gemmules contains a series of small circular cells, which make their escape when the containing envelope is ruptured. The gemmules in freshwater sponges are generally found in the oldest portions near the base, and each one is protected by a framework of bundles of acerate spicula of the flesh, as shown in Plate XI. fig. 16, but in many marine species, as *Geodia* and *Pachymatisma*, they are principally confined to the crust. In the freshwater sponges, the amount of animal matter in the gemmules is considerable; but in *Pachymatisma*, *Geodia*, and many other marine species, a very small quantity only is ever to be found, the substance of each gemmule being almost entirely composed of minute siliceous spicula; and if they be viewed when taken fresh

from the sponge, and after boiling in acid to remove the animal matter, a slight increase in transparency is the only perceptible difference of appearance in these two opposite conditions.

A p 73. Gemmules of a freshwater Sponge, *Spongilla fluviatilis*, after having been slightly treated with acid to remove a portion of the animal matter on their outer surface. When examined with a power of 100 linear, this surface appears studded with innumerable stellate bodies, as shown in Plate XI. fig. 19 ; but when the transparent edge is brought into view, it will be seen that the superficial stellate bodies are connected with a deeper layer by means of a stalk or pedicle ; and if the outer surface be crushed, or if the boiling in acid have been carried to a considerable extent, the siliceous particles composing the crust will be detached, and they will then be found to be spicula of the form termed bi-rotulate, from their resemblance to an axle with two wheels attached to it. The free surface of the spicula, and their mode of arrangement, is shown in Plate XI. fig. 20, the former being represented at *a*, the latter at *b*. The spicula in their fresh state are covered with membrane, and they are attached by their stellate bases to a firm yellow horny capsule.

A p 74. Spicula obtained from the gemmules of *Spongilla fluviatilis*, by boiling in nitric acid ; they are entirely detached from all animal matter, and occur singly ; when viewed with a power of 600 diameters, as shown in Plate XI. fig. 21, their true shape, and at the same time their resemblance to an axle having a wheel at each end, can be well seen ; the length of each spiculum on an average is about $\frac{1}{800}$th, and the diameter of one of the wheels about $\frac{1}{500}$th of an inch.

A p 75. Gemmules obtained from a Sponge, *Geodia Mulleri*; they are either oval or spheroidal in figure, and their outer surfaces are rough from the projection of the free extremities of the component spicula, which are all more or less angular. In each gemmule there is a white spot ; this is the pore or aperture of communication with the interior. On an average they measure $\frac{1}{350}$th in the long, by $\frac{1}{400}$th of an inch in their short diameter.

A p 76. Gemmules obtained from a Sponge, probably of the genus *Geodia*; in point of figure the fully developed specimens resemble those of the preceding preparation, but there are others of circular figure as small as $\frac{1}{2000}$th of an inch in diameter; from these the spicula project in the form of spines, as shown at *i* in Plate XI. fig. 10, and specimens may be found varying from this small size to the $\frac{1}{250}$th of an inch in diameter. All these gemmules exhibit a more or less distinct trace of the central pore, and in proportion to their development their outer surfaces are either covered with spines or tubercles, the former being the condition of the youngest gemmules, the latter that of the oldest. The specimens marked *i*, *e*, *c*, *d* and *g* in Plate XI. fig. 10, which are present in this preparation, are examples of the successive stages of growth of the same kind of gemmule; *i* being one in an early condition with projecting spines, and *g* another fully developed with more or less angular tubercles. Small sphero-stellate spicula occur amongst the gemmules.

A p 77. Gemmules obtained from a Sponge, probably of the genus *Geodia*; they are very similar both in size and figure to those of the preceding preparation, and like them also exhibit examples in various stages of development. Stellate spicula are also present in this specimen.

A p 78. Gemmules of *Pachymatisma Johnstonia*, which, with very few exceptions, are of oval figure, and in various stages of development. These gemmules exhibit better than any of the preceding, the stage represented at *d* and *e* in Plate XI. fig. 10, viz. where the spicula are still either sharp-pointed or in process of becoming tuberculated. The shape of the individual spicula is well shown in these gemmules immediately around the margin of the pore. Small radiated spicula, and others of the biternate variety, occur in considerable numbers amongst the gemmules.

Presented by J. S. Bowerbank, Esq., F.R.S.

A p 79. Gemmules from a Sponge, probably of the genus *Geodia*, found in the interior of a large horny sponge of commerce. They are mostly of an oval figure, being on an average $\frac{1}{300}$th of an inch in their long diameter, and are remarkable for the large size of the spicula, as denoted by the

tubercles and spines occurring on their outer surface, many of which are $\frac{1}{4000}$th of an inch in diameter. Numerous minute stellate spicula are present, one variety of which, as described in Preparations A p 61, 62, has the ends of the rays dilated and spinous.

Presented by Mr. J. T. Norman.

A p 80. Gemmules obtained from a Sponge, probably of the genus *Geodia*, found in the interior of a horny sponge; they are of small size, almost invariably spherical in figure, and never much exceeding $\frac{1}{350}$th of an inch in diameter. Like those of the preceding preparation, they are remarkable for the large size of the spicula, which in some cases exceed $\frac{1}{4000}$th of an inch at their free extremities. Many minute multi-radiate and stellate spicula are present with the gemmules, but none of them have dilated extremities like those in Preparation A p 79.

Presented by Mr. J. T. Norman.

A p 81. Gemmules obtained from a Sponge of unknown genus, but which are remarkable for exhibiting the radiated arrangement of the individual spicula: one of these is shown at *a* in Plate XI. fig. 10; in the same specimen may be seen smaller gemmules with coarse tuberculated surfaces, as shown at *b* in the same figure; there are also others of irregular shape, probably abnormal forms, as shown at *f* and *h* in the same figure.

A p 82. Gemmules obtained from a Sponge, probably of the genus *Geodia*, which are remarkable for their large size; their shape is either oval or spheroidal, and their component spicula, judging from the tubercles on the outer surface, are very numerous, but of small size. These specimens exhibit much more plainly than any of the preceding, the circular pore or aperture of communication with the interior, its diameter being $\frac{1}{5000}$th of an inch; the tubercles of the spicula forming the margin of the pore are larger than those in other parts of the surface. The average diameter of one of these gemmules is $\frac{1}{180}$th of an inch.

A p 83. Gemmules from a Sponge of unknown genus; they are of small size and mostly of an oval figure; some of them are indented in the middle, which

gives them a kidney-shaped appearance; their component spicula are also small, but the pore is of large size in comparison with that of the spicula themselves. In this specimen there are a few other kinds of gemmules, and numerous fragments of straight spicula remarkable for their size, and for the large diameter of the central canal; some of them when broken transversely exhibit upwards of twenty concentric rings. The average long diameter of the gemmules is $\frac{1}{400}$th, that of the short $\frac{1}{650}$th of an inch.

A p 84. Two portions of the crust of a small Sponge, probably of a genus allied to *Pachymatisma*, exhibiting numerous gemmules. They exist in great abundance in this part of the specimen, and are remarkable for their peculiar figure, which is more or less elongated or boat-shaped, as shown in Plate XI. fig. 17. Their outer surface, as shown in fig. 18 under a power of 600 diameters, is thickly covered with minute equal-sized angular tubercles, being the ends of the component spicula; in the centre of each gemmule the tubercles are absent for a space about $\frac{1}{5000}$th of an inch in diameter; this no doubt is the pore, but its margins are not so well defined as those in the other forms of gemmules. Spicula of various other kinds are found in this sponge, the most common being the acerate and the radiate, the latter being of the same shape, but smaller in size than those in *Pachymatisma Johnstonia*.

A p 85. Gemmules obtained from the crust of the same Sponge by boiling in nitric acid; they are all detached from the animal matter, and can be readily examined. Their shape is variable, but all are more or less elongated, having rounded extremities, and the middle of larger diameter than the other parts. The outer surface is thickly studded with minute angular tubercles, as shown in Plate XI. fig. 18, these being the ends of the spicula; the situation of the central pore is known by the absence of the tubercles. In some specimens the spicula may be seen radiating from a central point, but in this preparation few if any gemmules occur in which they can be traced to the circumference. The acerate and radiate forms of spicula are here well displayed. The average length of the gemmules is $\frac{1}{100}$th, the breadth $\frac{1}{500}$th of an inch.

A p 86. Gemmules obtained by boiling in acid from another portion of the crust of the same Sponge; they are precisely like those of the two preceding specimens, but amongst them may be noticed others of similar figure, without any appearance of tubercles on their outer surface. Occasionally, however, some fragments or even entire gemmules may be seen, in which the spicula may be traced radiating from the centre to the circumference. There are other specimens also occasionally visible, in which the outer surface of the gemmule has been as it were removed, and nothing remains but the radiating spicula; these are no doubt gemmules in an early stage of development, and answer to the spinous kinds described in various species of *Geodia* and *Pachymatisma*.

A p 87. Gemmules and spicula of various kinds, obtained from a Sponge of unknown genus, but which has afforded material for Preparations A p 80, 31 and 71; the only structures here requiring mention are gemmules, which resemble in very many points those described in the three preceding preparations; the surfaces of both are similarly tuberculated, but the shape of these is rather different, being for the most part broader and shorter than those before described, as may be seen at *b* in Plate X. fig. 11; that however represented at *a* is lozenge-shaped, but is rare as compared with that shown at *b*. Another important difference between these and the preceding specimens, consists in the manner in which the pore is displayed; in these, as shown at *g*, it is very evident, but in the others the only indication of it is a white spot. Some few examples of imperfectly developed gemmules, in which the spicula may be traced from the centre to the circumference, are also present in this preparation. The average length of one of these gemmules is $\frac{1}{140}$th, the breadth $\frac{1}{350}$th of an inch.

A p 88. Gemmules obtained from a Sponge found at Madeira, and named by Mr. Bowerbank *Pachymatisma Listeri*, in honour of Dr. Lister, the discoverer. They consist of small bodies of irregular shape, sometimes more or less flattened, their edges not unfrequently being jagged or toothed like some of the spicula of Gorgoniæ. Their outer surface is covered with minute tubercles, smaller in size and less numerous than those in the preceding specimens, but sufficiently like them to prove that

these curious bodies are really gemmules. In some specimens the individual spicula may be well seen, but they are not so numerous as those in the preceding preparations; many of them do not appear to reach the surface, consequently this part of the gemmule is not regularly studded with tubercles; but the spicula, being more or less arranged in groups, give to the surface a very rough and uneven appearance. The gemmules are on an average $\frac{1}{400}$th of an inch in the long, by $\frac{1}{800}$th in the short diameter. *Presented by J. S. Bowerbank, Esq., F.R.S.*

A p 89. A similar specimen from *Pachymatisma Listeri*, in which the gemmules and spicula are both more abundant than they were in the preceding preparation. In many of the gemmules the spicula appear to be arranged in circles, and on this account a series of small rings of the projecting tubercles may be noticed on the free surface. As in other species of *Pachymatisma*, gemmules may be found in different stages of growth; the youngest specimens being covered with spines, so in this, examples are present in which the outer margins are covered with the ends of the projecting spicula; these, however, are not numerous, but of large size in proportion to that of the gemmules. One form of spiculum in this Sponge is worthy of notice; it is of the variety known as fusiform, and is about $\frac{1}{400}$th of an inch in length, and $\frac{1}{4000}$th in diameter in the centre, this part being the largest. Other spicula of a similar shape, but smaller and slightly tuberculated, are also met with in tolerable abundance. The ordinary large acerate, and the minute radiated forms so characteristic of this genus, are also present.

Presented by J. S. Bowerbank, Esq., F.R.S.

A p 90. A portion of the fibro-siliceous skeleton of a Sponge, *Dictyochalix pumiceus*, taken from the same specimen as Preparation A p 10. The fibres are of two kinds; one more or less broad, covered with small projecting tubercles, and arranged in the form of a coarse network; the other thin, slightly spinous, and connected with the first in such a manner as to form with it a finer network between some of the larger meshes. Portions of the latter kind may often be detached from the coarse meshes in the form of branched or radiating spicula: their true

shape and mode of union can then be well studied; they will be found to consist of a central portion or shaft, with which are connected four or more rectangular arms, the point of junction being dilated into a round knob; the arms are most frequently of uniform length, and both they and the shaft also terminate in a rounded knob like that of the head of a pin; by the knobs these spiculum-like bodies are articulated with the coarse framework. Within the meshes may occasionally be seen some stellate spicula, that have been described as gemmules; they are of two kinds, one consisting of a small centre, from which radiate numerous small sharp pointed spines, the other also composed of a circular nucleus of small size, from which radiate numerous arms having knob-like extremities; this last form of spiculum is exceedingly like a series of pins stuck into a small round cushion; both forms are nearly alike in size, and measure on an average $\frac{1}{400}$th of an inch in diameter.

Presented by J. S. Bowerbank, Esq., F.R.S.

A p 91. Another portion of the same Sponge exhibiting the framework in more or less detached pieces; some of the long spiculum-like bodies with radiating arms may also be seen separated from the coarse framework; when perfect each extremity terminates in a knob, and a series of corresponding depressions or sockets may be observed in the coarse framework for the reception of the knobs. The supposed gemmules also are present; some of them occur singly, others are closely connected together in groups, and are lodged in the meshes formed by the union of the large and small fibres. *Presented by J. S. Bowerbank, Esq., F.R.S.*

All the specimens depicted in Plate XI. have now been described, with the exception of the stellate bodies represented in fig. 14; these at first were supposed to belong to one of the family of Sponges, and as such were placed in this Plate. They have since however been discovered to be a part of the skeleton of an animal higher in the scale of organization, probably a tunicated Mollusk; but as their true position is still a matter of doubt, it has been thought proper to describe them in this place.

A p 92. A portion of the outer integument or crust of an invertebrate animal,

probably a tunicated mollusk, in which are imbedded numerous calcareous stellate bodies of the shape represented in Plate XI. fig. 14; they vary much in size, some being as small as $\frac{1}{1300}$th, others as large as $\frac{1}{600}$th of an inch in diameter. These spicula differ from those of the genus *Tethea* and other sponges, not only in being calcareous, but in wanting the central nucleus. *Presented by J. S. Bowerbank, Esq., F.R.S.*

A p 93. Spicula of a similar kind, obtained from an animal attached to the shell of a large Pinna; they were dried before being mounted in the Canada balsam, which has rendered them exceedingly brittle, and will account for the large number of fragments that are mixed up with them. These spicula, both in figure and chemical composition, resemble those of the preceding preparation.

Subseries III. *Skeleton of Diatomaceæ and Infusoria.*

The lowest forms of vegetable life are known as *Algæ*, and are described as cellular flowerless plants, nourished through their whole surface by the medium in which they vegetate, living in water or very damp places. They are divided into five natural orders, the only one here requiring notice being the first, or that known as *Diatomaceæ* or Brittleworts, which are characterized as crystalline angular fragmentary bodies, brittle and multiplying by spontaneous separation. This order is subdivided into three others; of these, the first, or *Cymbelleæ*, are distinguished from the rest by possessing a siliceous skeleton, and as such belong to the present series of hard tissues.

With few exceptions, all the genera of *Diatomaceæ* have been described by Ehrenberg as Polygastric Infusoria of the family Bacillaria, whilst Kützing, Agardh and other high authorities consider them as *Algæ*. As this point however is still *sub judice*, and as certain of the Infusoria as well as *Algæ* have a siliceous skeleton, it has been thought best to include both in the same subseries, leaving their true position in the scale of nature for future determination. It is quite certain however that these organic bodies form a connecting link between the vegetable and animal kingdoms, as they possess certain characters peculiar to both, and therefore may be said to be the common property of the botanist

and zoologist; neither must they be passed over by the geologist, as from their possessing siliceous coverings, they are not only found in a fossil state widely diffused in all parts of the globe, but in some situations are so abundant as to form characteristic strata of considerable thickness and many miles in extent. Some kinds have also been largely employed in the arts, whilst others, from their resemblance to flour, it is stated have not unfrequently been used to adulterate that important article of food.

The *Diatomaceæ* or *Bacillariæ*, when recent, are of a brownish-green colour, and in shape mostly prismatic or quadrilateral; the flinty skeleton is composed of one or more pieces, each of which is generally marked either with lines or dots, in some cases so delicate as to require the highest powers of the microscope even to perceive them, much more to ascertain their true nature. They are inhabitants both of salt and fresh water, and most frequently occur in clusters.

A q 1. Recent freshwater *Bacillariæ* known as *Meridion circulare*, consisting of a series of wedge-shaped bivalve siliceous loricæ arranged in spiral coils, which when perfect and in certain positions resemble circles; each lorica is articulated by two lateral surfaces, presenting a row of dots varying very much in number; minute striæ in some cases extend from each dot towards the middle of the lorica, and on the circumference there are two of such dots. The spirals and the individual loricæ are very fragile, and therefore easily separated from each other. Portions of two of the spirals are shown at *a*, *b* in Plate XII. fig. 2, under a magnifying power of 100 diameters, and five of the loricæ at *c* under a power of 300.

Presented by Prof. J. W. Bailey, West Point, New York.

A q 2. A series of ribbon-like filaments, known as *Fragillaria pectinalis*, each consisting of an aggregation of bivalve siliceous prismatic loricæ, twice or three times longer than broad, the articulating surfaces presenting very minute striæ. Three of the ribbons are represented in Plate XII. fig. 15; they may be viewed either as opaque or transparent objects; in the former condition they are of silvery whiteness, and, like the *Meridion*, are, as their name implies, exceedingly fragile.

Presented by Prof. J. W. Bailey.

A q 3. Loricæ of *Diatoma flocculosum* in an early state, each of which is of a more or less square figure, and articulated to its neighbours by opposite angles; four to seven long striæ are occasionally found on each side of the loricæ. A few specimens of the same *Diatoma* may be seen in other parts of the preparation in a more advanced stage, the loricæ being much longer than broad. The early condition of the loricæ is shown in Plate XII. fig. 13, the fully-developed in fig. 14.

Presented by Prof. J. W. Bailey.

A q 4. Frustules of *Diatoma elongatum*, which are longer in proportion to their breadth than those of *D. flocculosum*; they are of uniform size, and have on an average four longitudinal striæ on each surface. Six of the loricæ are represented in Plate XII. fig. 14 *a*.

Presented by Prof. J. W. Bailey.

A q 5. Specimens of *Gomphonema geminatum*, each of which is fixed upon an immoveable horny stalk. The loricæ are wedge-shaped, and are composed of two or more pieces, having, according to Ehrenberg, two openings at the broad end; this last is either hemispherical or indented. Each broad surface is transversely striated. These creatures it is said, when detached from their stalks, can creep about on plants as independent beings. They are found both in the recent and fossil state; a recent specimen is represented in Plate XII. fig. 4.

A q 6. Specimens of *Cocconema Boëckii*, composed of two lanceolate loricæ, broad in the middle and tapering gradually towards both extremities, one of which is attached to a pedicle. Each lorica has a central linear marking, with transverse rows of dots on both sides of it; according to Ehrenberg there are twenty-six rows in $\frac{1}{100}$th of a line. Three specimens are represented in Plate XII. fig. 7.

Presented by Richard Beck, Esq.

A q 7. Another species of the genus *Cocconema*, being the *lanceolatum* of Ehrenberg; it differs from the preceding in having one margin of the loricæ of a semicircular figure, and also in being of larger size, more coarsely

marked, and in having a lozenge-shaped spot or opening in the centre of each lorica. Three specimens are represented in Plate XII. fig. 6.

Presented by Richard Beck, Esq.

A q 8. Specimens of *Achnanthes longipes*, the loricæ of which are of a prismatic figure, and consist of four or more pieces, two of them being convex and coarsely dotted: these appear to form the margins; the other two are more internal, and partially covered with finer striæ; the loricæ are attached by one corner to a pedicle, and have on this account been compared to a standard: all the specimens exhibit green matter in their interior. The pedicles are jointed, and some of them also contain numerous green granules. A few examples of this species are represented in Plate XII. fig. 8, some of them being single, others double and about to divide. *Presented by Richard Beck, Esq.*

A q 9. Specimens of the same species of *Achnanthes* mounted in Canada balsam; the loricæ are now generally to be found in detached pieces, some of them having, besides the rows of dots, only a longitudinal marking in the centre; others, and these slightly curved, have the longitudinal marking, and another at right angles as well, with a dilated spot where the two join; in these last the rows of dots are also more numerous than in the first, and this lorica is the one to which the pedicle is invariably attached.

Presented by Richard Beck, Esq.

A q 10. Specimens of a fossil *Eunotia* found in earth from Bermuda; the loricæ are siliceous and four in number, of a semi-lanceolate figure, slightly indented on both margins; two of the surfaces, which may be called dorsal and ventral, are covered with strongly marked curved rows of dots, whilst the two lateral have their margins only partially striated with finer rows of dots. A single specimen is represented in Plate XII. fig. 5. According to Ehrenberg, in recent examples there are four openings in the loricæ, all situated on the same side.

A q 11. Earth from Santa Fiora, Italy, in which are numerous specimens of *Eunotia zebra*; they are of a semi-lanceolate oblong form, and have their dorsal and ventral surfaces covered with rows of close-set dots, there being

about forty rows on each surface. They vary much in size, some being as large as $\frac{1}{500}$th, others as small as $\frac{1}{1500}$th of an inch.

Presented by Mr. J. T. Norman.

A q 12. Earth from the river Upper Bann, Ireland, remarkable for containing a large number of short cylindrical-jointed bodies flattened at both ends; these are known as *Gallionella distans*, and are also common in the slate of Bilin, and in the Berghmehl of Sweden. Longitudinal striæ exist on the outside of many of the joints, and others in the form of radii may be seen extending from the margin towards the interior of the shorter joints.

A q 13. Earth from Richmond, North America, abounding in very beautiful siliceous shells, the only one here requiring notice being *Gallionella sulcata*, which consists of chains of cylindrical bivalve loricæ, having their outer surfaces marked or furrowed with longitudinal striæ; short joints may occasionally be seen having their ends uppermost, the depth of the furrows being shown on the margin; within the margin is a thin transparent rim having radiating striæ. In some cases, as many as forty individuals have occurred in one chain in this stratum of infusorial earth. This species of *Gallionella* is found in the recent as well as in the fossil state, in many parts of North America. Portions of two chains are represented in Plate XII. fig. 10. *Presented by Prof. J. W. Bailey.*

A q 14. Earth from Bohemia, particularly rich in fossil specimens of *Navicula viridis*, which consist of four prismatic loricæ, two ventral and two lateral, the former having round, the latter truncate extremities, and both provided with two rows of transverse markings or dots, longer and more marked on the ventral than on the lateral surfaces. The specimens having one of their ventral surfaces uppermost, exhibit a longitudinal marking in the centre with a slight dilatation or knob at each extremity; this marking is interrupted in the middle of the lorica, and a diamond-shaped spot is left; if one of the lateral loricæ be examined, two of the same spots will be seen, one on each side; they are of triangular figure, and appear to be thicker parts of the shell and not holes, as Ehrenberg

has imagined. Four smaller triangular spots may be observed in the same lorica, one being situated at each corner; these also have been considered as openings by Ehrenberg. The ventral aspect of one of these specimens is represented in Plate XII. fig. 1 *b*; their length varies considerably; some exceed $\frac{1}{100}$th, whilst others are even smaller than $\frac{1}{1000}$th of an inch. This species is one of the finest and most universally diffused of all the *Naviculæ*, and may be met with in a recent state in nearly every pond in the neighbourhood of the metropolis.

A q 15. Recent specimens of *Navicula viridis* from New York, exhibiting characters precisely similar to those found in the fossil state, the orifices at each corner of the lateral loricæ being well-marked. With these may be seen another species of *Navicula*, remarkable for having a broad transverse band across the centre, which, with two others in the longitudinal direction, form a well-marked crucial appearance. This latter species is described in Preparation A q 19. *Presented by Prof. J. W. Bailey.*

A q 16. Earth from Santa Fiora, Italy, which, in addition to other very numerous species, contains a *Navicula* of large size, known as *grandis*; in many of its characters it resembles the species last described, but it differs from it in being larger, and not having parallel, but slightly undulating margins. The two species are represented side by side in Plate XII. fig. 1, *a* being the *grandis*, and *b* the *viridis*; the openings at either extremity are much more plainly shown in the former than in the latter species. In this preparation there are specimens as large as $\frac{1}{50}$th of an inch. Although the striæ are so well marked, their true nature cannot be so well determined as those in some of the smaller species. *Presented by Mr. J. T. Norman.*

A q 17. Earth from Cartel del Piano, in which are specimens of *Navicula grandis* as large as $\frac{1}{40}$th of an inch, presenting all the characters of those described in the preceding preparation.

Presented by Mr. S. W. Leonard.

A q 18. Earth from Dolgelly, North Wales, containing the siliceous loricæ of a species of *Navicula* of an oval figure, $\frac{1}{50}$th of an inch in the long, by $\frac{1}{200}$th in the short diameter, and having a row of rounded markings on both edges

of the ventral surface, the lateral surfaces being very thin and minutely striated. The Naviculæ are very remarkable for having the space between the ventral loricæ, which may be termed their internal cavity, filled with fragments or entire specimens of other organic remains found in the same earth.

Presented by Abel Ingpen, Esq., A.L.S.

A q 19. Specimens of recent Naviculæ from New York, remarkable for having two grooves or elevated ridges passing from one extremity of the ventral surface to the other; in the centre they slightly expand and join a broad flattened band passing transversely, so that a cruciform appearance results, and the surface is divided into four symmetrical parts. No striæ or dots are to be seen upon any portion of the loricæ of this species of *Navicula*. Many specimens of *N. viridis* are also to be found in this preparation.

Presented by Prof. J. W. Bailey.

A q 20. Specimens of a *Navicula* somewhat similar to the last, but obtained from earth found at New Plymouth, New Zealand; each ventral surface has the two parallel ridges running from one extremity to the other, but in the centre, instead of a broad transverse band joining them, there is one composed of a double wedge, like half a Maltese cross, the broad ends of which are close to the circumference of the lorica, as shown in Plate XII. fig. 26. Under a power of 250 diameters, the surface appears marked with wavy striæ; but with one of 500 diameters, and careful manipulation, they will be found to be produced by oblique rows of dots, the dots in one row not being in the same line with those in the rows immediately above and below them. The average length of a specimen is $\frac{1}{130}$th, and the breadth of the same $\frac{1}{360}$th of an inch. In the same earth may be seen another peculiar form of *Navicula*, somewhat resembling that described in Preparation A q 18, being of an oval figure, $\frac{1}{90}$th of an inch in the long, by $\frac{1}{160}$th in the short diameter; its margins are marked with semicircular lines internally, and from each line a small linear rib passes across to the opposite margin. The specimens appear to be only single loricæ, and have their internal surface uppermost; this is concave, and the entire lorica very much resembles a boat in shape.

Presented by Gideon Algernon Mantell, D.C.L., F.R.S.

A q 21. Specimens of *Isthmia enervis* attached to sea-weed, *Ceramium*; according to botanists they are Algæ, of the family *Diatomaceæ*, but according to Ehrenberg Infusorial animals of the family *Bacillaria*. Each is of a trapezoid shape, and consists of three parts; the one in the centre being bounded by straight broad lines, and appearing in the form of a transverse band; its outer surface is covered with a network of rounded reticulations arranged in parallel lines, whilst the terminal portions are more coarsely reticulated. In some specimens there are two or more transverse bands: these are only to be found in such as are young; and on careful examination it may be seen that two individuals are inclosed within the shell of an old one; all are attached to one another, or to portions of sea-weed by a short stalk. Three specimens are represented in Plate XII. fig. 11. *Presented by C. G. White, Esq.*

A q 22. Specimens of *Isthmia obliquata*, which, like the preceding species, are attached to a portion of sea-weed, *Ceramium*; they are rather smaller in size and shorter than *I. enervis*. The reticulations on the central band are sometimes arranged in oblique lines, but those on the terminal portions have strong ribs in addition to the reticulations, as shown in Plate XII. fig. 12. *Presented by John Ralfs, Esq., M.R.C.S.*

A q 23. Siliceous skeletons of *Biddulphia pulchella*, being somewhat of the same nature as those of *Isthmia enervis*. Each consists of three portions, the one in the centre being more or less square, and those at the end, which may be called lateral, having either one or three rounded projections between the angles; but the last always exceed the projections in length. From the sides of the central portion large striæ or ribs proceed as far as the margins of the projections; in some cases the striæ are divergent, in others united by anastomosing lines; the angles in some of the larger specimens are also surrounded by a line. The entire surface of each specimen is covered with rounded projections or dots: these, as in *Isthmia*, are smaller in the central than in the lateral portions. An entire specimen, and a part of another connected with it in the same case, are represented in Plate XII. fig. 3; this being the condition in which very many are found. In the recent state, when young, they are attached to each other by the

angles, but occasionally they form a zigzag chain; in these cases they cohere by the alternate angles only.

Presented by Matthew Marshall, Esq.

A q 24. Siliceous skeletons of *Amphitetras antediluviana*; they are of a cubical or box-like figure, and consist of three portions, the one in the centre being in the form of a band, as shown at *a* in Plate XII. fig. 9, and the two lateral having four slightly projecting angles with an opening in each. When viewed in detached pieces the central one is like a box, and the two lateral portions resemble the cover and bottom. The former may be readily known, as consisting merely of a square framework with striated sides, but both the latter, as shown by *b c*, are marked with radiating reticulations. When recent, they are found in zigzag chains, from their cohering only by alternate angles. In some instances, as in *Biddulphia* and *Isthmia*, two young specimens may be found within an old one.

Presented by Matthew Marshall, Esq.

A q 25. Small siliceous loricæ belonging to the genus *Cocconeis*, found attached to a sea-weed from Algoa Bay. They are oval in shape, convex on one surface, concave on the other, and when viewed with a power of 100 diameters exhibit from eight to ten lines on each side, passing from the inner margin of the lorica towards the centre, as shown in Plate XII. fig. 19 *a*, *b*; when however a power of 500 diameters is employed, as shown at *c*, it will be seen that between the lines there are numerous striæ composed of dots, which in some cases join those from the opposite side, but about the centre they stop short and leave a small triangular clear spot, as in many of the *Naviculæ*. In some specimens the lines are more strongly marked than in others, and a single one may be seen in the centre extending from one end to the other; with this, those from the margins communicate. In a few specimens there is an appearance of oval as well as of radiating striæ.

Presented by J. S. Bowerbank, Esq., F.R.S.

A q 26. Earth called Kieselguhr from Soos, near Eger in Bohemia, containing large quantities of *Campylodiscus clypeus*; they are of an oval figure, and

are curved twice in opposite ways, once in the direction of the long, and once in that of the short diameter; the former renders the upper surface convex to the eye, whilst the latter gives it a grooved appearance, and on the whole they resemble an ancient shield. The markings on their surfaces may be divided into two kinds, viz. those situated on the margin, and those in the oval centre; the former consist of two series of wedge-shaped bodies covered with dots, sometimes arranged in lines; and the latter have numerous dots on the margin, but very few in the centre. Two specimens in different positions are represented at *a*, *b* in Plate XII. fig. 20.

A q 27. Earth from Richmond, North America, containing many specimens of the genus *Actinocyclus*, which is characterized by being composed of cylindrical bivalve siliceous loricæ, divided internally by radiating partitions; the specific name is derived from the number of cells formed by the partitions. The most common species in this preparation is that having six cells and called *senarius*; others may be found of larger size, having as many as twenty cells. In some specimens all the cells appear to lie on one plane, in others every alternate cell only is in the same plane, so that when a high power is employed one set alone can be distinctly seen at a time. The markings of all the species are nearly of the same nature, differing only in degrees of fineness, the small *senarius* having a coarser hexagonal network than specimens double its size. The variety of species in this single preparation is so great, that it would occupy too much space to describe them.

A q 28. Earth from Bermuda, containing many species of *Actinocyclus*; one here requires particular attention as having a beautifully raised margin, and a five-rayed star in the centre; the number of cells is ten, five being on one plane and five on another. One set has the usual hexagonal reticulations crossed with diagonal lines, the other has the same lines with a much smaller series of triangular reticulations, so disposed that they appear to form with each other, parts of minute circles. One of the valves of this specimen is represented in Plate XII. fig. 17.

A q 29. Earth from Richmond, North America, containing numerous bivalve

sieve-like discs of various sizes, belonging to the genus *Coscinodiscus* of Ehrenberg. All the species are marked with an hexagonal network of cells, sometimes disposed in parallel or radiating lines, or in circles. The species here to be described is known as *C. lineatus*; it measures on an average $\frac{1}{600}$th of an inch in diameter: the hexagonal cells or markings on its surface are of uniform size, and arranged in parallel lines.

A q 30. Another specimen of the same earth, in which may be seen a species of *Coscinodiscus* known as *radiatus*; it is of larger size than the preceding one, being in some cases $\frac{1}{250}$th of an inch in diameter; the cells are nearly uniform in size over the great part of the surface, but are smallest on the margin; all of them are disposed in radiating lines.

A q 31. Valves of *Coscinodiscus Argus*, obtained from Ichaboe guano, being probably only a variety of *C. lineatus*; the cells are largest in the centre, and gradually diminish in size towards the margin; all of them, however, are disposed in radiating lines. The shape of the valves resembles a meniscus watch-glass.

A q 32. Another radiated form of *Coscinodiscus*, obtained from the Richmond earth; the cells are smallest in the centre, and gradually increase in size towards the margin.

A q 33. Another species of *Coscinodiscus*, obtained from Bermuda, belonging probably to the species known as *Oculus iridis* of Ehrenberg; the cells in the centre are arranged in the form of a star, the others are disposed in radiating lines as in *C. radiatus*, those on the margin being smaller than the others. A portion of a valve of this specimen is represented in Plate XII. fig 18.

A q 34. A peculiar form of *Coscinodiscus* found in the earth from Bermuda, having on one of its valves two parallel rows of oval cells arranged at right angles to each other in the form of a cross; the cells being smallest in the centre, and increasing in size towards the margin, which is thicker and more elevated than in many of the other species. The spaces between the arms of the cross are occupied with radiating hexagonal cells of the usual figure. This preparation is represented in Plate XII. fig. 16.

Presented by Mr. S. W. Leonard.

A q 35. Siliceous loricæ, obtained from Ichaboe guano, most of which belong to the genus *Coscinodiscus*; one species, however, of circular figure, and remarkable for its blue colour, here deserves mention. The specimens vary much in size, some being as small as $\frac{1}{800}$th, others as large as $\frac{1}{200}$th of an inch in diameter; all present peculiar markings, consisting of very minute hexagonal cells of uniform size disposed in radiating lines, which, however, do not reach as far as the margin, but leave this free and apparently structureless. In most of the larger specimens about every sixth row of radiating cells is further apart than the others, and a white line or ray is caused thereby; the entire series of these make the lorica appear marked like that of an *Actinocyclus*. Some of the loricæ are nearly flat, others either slightly convex or concave, but all possess the light-coloured rim or margin. In this preparation are loricæ having markings like the blue specimens, but of a dark gray colour.

A q 36. Earth from Petersburg, North America, containing a siliceous lorica of remarkable beauty, known as *Tripodiscus Rogersii*; it is slightly concave, and its surfaces are marked with reticulations or cells, somewhat like small stars; these, as in *Coscinodiscus radiatus*, being arranged as so many radii. When perfect, two loricæ or valves, shaped like watch-glasses, are adapted to each other so as to form a box; from each lorica three small curved feet project; hence the name *Tripodiscus*. Under a certain arrangement of the light there may sometimes be seen upon the convex surface a series of hexagonal reticulations, as in *Coscinodiscus*; and the star-shaped cells before alluded to appear to be nothing more than the spaces between the reticulations which happen to be of a stellate figure.

Presented by Prof. J. W. Bailey.

A q 37. A siliceous lorica of *Arachnoidiscus Moxhayi*, so named by Mr. H. Deane, from its resemblance to a spider's web; recent examples occur on sea-weed from Japan, which is used occasionally as an article of food. A perfect specimen, according to Mr. Shadbolt, consists of two discoid loricæ and two annular valves. Each lorica is covered externally by a thin horny membrane, on which are the spider's web-like markings, and the silica forming the skeleton is applied to the inner surface of this membrane,

its arrangement being like that of a Gothic window. Each lorica has a central aperture, around which a series of oval and circular reticulations are disposed; the spaces between the radii are occupied by smaller reticulations, so arranged in the entire lorica as to form a series of concentric rings. Projecting from the margin of each lorica towards the centre may be seen a long ray having a shorter one on either side of it, so that in certain aspects the margin appears divided like a circular micrometer. One of these specimens is represented in Plate XII. fig. 21; they vary much in size: this one measures $\frac{1}{70}$th of an inch diameter.

A q 38. A siliceous lorica of triangular figure, obtained from the mud of the Thames, and known as *Triceratium favus*. It consists of little else than a series of cells or reticulations of hexagonal figure, and having from each angle a small curved horn or foot projecting; hence the name *Triceratium*. The reticulations appear to be formed in the same manner as those in the various species of *Coscinodiscus*, and in this species are of uniform size.

A q 39. Earth from Bermuda, containing numerous species of *Triceratium*; one here requiring mention is smaller in size than the preceding specimen, and its angles are drawn out into sharp points. The reticulations on its surface are smaller than those in *T. favus*; but the feet, which may be seen close to the angles, are large in proportion to the size of the specimen. A single lorica is represented in Plate XII. fig. 22 *e*.

A q 40. A small species of *Triceratium* obtained from the same earth, remarkable for having one of its sides curved. The entire surface is covered with rather large reticulations, arranged somewhat in a radiating manner; the feet are small and situated at each corner. This specimen is represented in Plate XII. fig. 22 *b*.

A q 41. Another species of *Triceratium* obtained from the Bermuda earth; it is rather larger than the last-described specimen, and has all three of its sides slightly curved. The entire surface is covered with minute reticulations, following the curves of the margins, except at the angles, where

three large triangular feet or horns are situated. The reticulations of the margins are smaller and more prominent than those in other parts of the surface. This specimen is represented in Plate XII. fig. 22 *c*.

A q 42. Another species, either of *Triceratium* or of some allied genus, remarkable for the great extent to which the curvature of the sides has been carried. In appearance this specimen nearly resembles a tri-radiate spiculum of sponge; but its markings are precisely similar to those of *Triceratium*, being reticulations following the curves of the margins, which are very prominent. An example of this form of *Triceratium* is given in Plate XII. fig. 22 *d*.

A q 43. Earth from Richmond, North America, containing specimens of *Dictyocha*, one of which, from its resemblance to an ancient buckle, has been termed *fibula* by Ehrenberg. It consists of a concave rhomboidal body formed of open work, enclosing four large lateral perforations and a central one, and having from each corner of the framework a projecting spine. This specimen is not flat as might be supposed from the drawing, but the centre is much raised above the marginal framework.

Presented by Prof. J. W. Bailey.

A q 44. Earth from Bermuda containing a specimen of *Dictyocha fibula*, precisely similar to that described in the preceding preparation; it is represented in Plate XII. fig. 23. *Presented by Mr. S. W. Leonard.*

A q 45. Another species of *Dictyocha*, found also in earth from Bermuda; it is of very much smaller size than *D. fibula*, and consists of a framework having seven sides, from the angles of which seven rays proceed, and join a ring in the centre, so that seven lateral perforations and one in the centre are produced; from each angle seven spines also project; these are much longer in proportion than those in *D. fibula*.

A q 46. Earth from Petersburg, Virginia, containing siliceous loricæ of *Zygoceros Tuomeyi*. The loricæ have at each end two blunt horns with swollen bases, between which, on each side, there are generally from one to three globular projections, those in the middle being the largest, and often

bearing two spines; at the base of each of the swellings are three oval perforations. The surfaces of the loricæ are covered with minute hexagonal reticulations. *Presented by Prof. J. W. Bailey.*

A q 47. Earth from Petersburg, Virginia, containing specimens of *Zygoceros rhombus*; each one consists of three pieces or valves, one central and two lateral; the former is in shape like a band or zone, the latter are of a rhomboidal figure, curved, and having a projecting spine or horn at each extremity. All the valves are marked with minute dots, arranged diagonally like those of the *Navicula angulata*. An entire specimen is represented in Plate XII. fig. 24. *Presented by Prof. J. W. Bailey.*

A q 48. Earth from Piscataway, Maryland, containing remarkable loricæ somewhat resembling one of the species of *Navicula* in shape; the ventral surfaces of each are marked with upwards of thirty transverse rows of square dots or projections, but there is no central line or spot as in the *Naviculæ*. A specimen is represented in Plate XII. fig. 25; its long diameter measures $\frac{1}{400}$th, and its short $\frac{1}{2000}$th of an inch.

A q 49. Earth from Barbadoes, remarkable for the variety of forms of siliceous loricæ which it contains; many of them are so unlike any of the genera hitherto described, that it is difficult to determine to what order of beings they could have belonged; that some few of them are marine, may be shown by fragments of *Coscinodisci*, *Gallionellæ*, and other well-marked species that are present. One of the most common forms may be selected for description, out of the many varieties occurring in this preparation. In figure it is circular, and is composed of an open framework somewhat like that of the shell of an Echinus, but arranged in concentric zones one above the other, the openings in the framework being all of a circular figure; from the margin six or more strong sharp spines project. Other bodies of larger size also occur in tolerable abundance, in which there is no trace of concentric zones, but the reticulations or cells of the framework are disposed in a radiating manner; some have a few, others no spines projecting from their outer margin. All these last-described specimens are more or less convex.

Presented by J. S. Bowerbank, Esq., F.R.S.

A q 50. Earth from Barbadoes, containing bodies of a globular figure made up of a cellular or reticular framework, from two opposite sides of which large conical spines project; these, like the spicula of sponges, are more or less round and provided with a central cavity. The specimens vary much in size; the one now under description measures $\frac{1}{250}$th of an inch in diameter, the spine being $\frac{1}{300}$th of an inch in length and $\frac{1}{1300}$th in diameter at its base. Other bodies of globular figure also occur, having many small spines projecting from their outer surface; some of these are straight, others slightly curved.

Presented by J. S. Bowerbank, Esq., F.R.S.

A q 51. Earth from Barbadoes, also containing many examples of the two peculiar forms above described, but in addition a body of the shape of a dome, having a short spine projecting from its summit and two conical diverging ones from its base, each being about $\frac{1}{140}$th of an inch in length. The part corresponding to the dome has circular reticulations or perforations of the same nature as those in the specimens above described. In this same preparation there are numerous other dome-shaped bodies, but the majority of them are smaller in diameter and more elongated than this one; some have a circle of small diverging spines projecting from their base, others have no spines at the base, but numerous very minute ones near the summit. *Presented by J. S. Bowerbank, Esq., F.R.S.*

A q 52. Earth from the shores of Lough Mourne, County Antrim, Ireland, extremely rich in the siliceous loricæ of Diatomaceæ; upwards of forty different species of which are to be found in this single preparation. They belong principally to the following genera, viz. *Navicula*, *Epithemia*, *Surirella*, *Synedra*, *Cocconema*, *Gomphonema*, *Stauroneis*, &c. According to the Rev. W. Smith*, this deposit is of recent date, by far the greater number of the species being still to be found alive in the waters of the lake. The earth when fresh is of a delicate cream colour, and after being cleansed by boiling in acid or when pulverized, is pure white, and has proved an excellent material for polishing silver plate.

Presented by G. Shadbolt, Esq.

* Annals of Natural History, vol. v. p. 121.

Subseries IV. *Skeleton of Zoophytes.*

Polypiphera.

The skeletons of these zoophytes are either external or internal to the soft parts, and are in some cases composed of a horny, in others of a calcareous material. They present many varieties of form and character, being not unfrequently soft, flexible and branched, as in some of the *Gorgoniadæ*, or solid and massive, as in the *Corallidæ*.

The simplest forms of the skeleton consist of a horny material surrounding the soft parts, either as tough flexible filaments or as a tube ; such skeletons are found in the *Alcyonidæ* and *Sertulariæ*, or the horny matter may be deposited in concentric laminæ, in the form of a stem within the soft parts of the animal, as in the *Gorgoniadæ* ; in some of these animals, however, the stem is composed of calcareous matter, as in the *Corallium rubrum*, the Red Coral of commerce. The exterior fleshy substance of these *Gorgoniadæ*, as well as that of the *Alcyonidæ*, is sometimes covered by a hard crust of calcareous spicula of various forms, as shown in Plate XIII. figs. 1 to 7 ; or similar spicula may be found firmly imbedded in the more internal parts of the animal matter ; the office performed by the spicula is without doubt analogous to that in the sponges before described.

In the Madrepores and Corals generally, the skeleton is internal, and is composed of solid masses of carbonate of lime mixed with a very small amount of phosphate ; many of these skeletons are remarkable for the beauty and elegance of their form ; they are found attached to rocks in tropical seas, and not only exist there as separate individuals, but many kinds by combined agency build up dangerous reefs and shoals : these in some cases reach the surface and form islands of considerable magnitude, which in process of time become covered with luxuriant vegetation.

In no instance are the skeletons of Zoophytes supplied with blood-vessels, neither are they altered in size when once deposited except by the addition of new material. The Polypi inhabiting the cells of the skeletons are not the essential agents in its formation, the fleshy mass of the body of the animal being alone concerned in this process ; a considerable portion of the skeleton, and even the

cells for the polypi are fully formed before the polypi themselves exist; these last, therefore, may be considered as parts of secondary importance.

a. *Skeleton composed of Horn.*

A r 1. A portion of *Laomedea gelatinosa*, consisting of a fleshy granular substance, surrounded by a skeleton of tough transparent horny material, which is expanded at certain points to form the cells for the polypi.

A r 2. A portion of the stem of a species of *Campanularia*, consisting of a tubular granular substance, surrounded by a sheath of transparent horny material, which forms the skeleton. As in the preceding specimen, the sheath is expanded at the extremity of every branch to form cells for the lodgement of the polypi; in the neighbourhood of each of these cells the sheath presents a wavy outline, and appears as if it were jointed, this being a provision to allow of a certain amount of flexibility in the cells themselves. A portion of the stem is represented in Plate XIII. fig. 10.

A r 3. A portion of the stem of *Gorgonia ceratophyta*, consisting of a soft animal crust surrounding a central horny stem or skeleton; this last, when divided transversely, as shown in Plate XIII. fig. 14, is found to be composed of concentric layers of brown structureless matter very much resembling horn.

A r 4. A transverse section of the stem of *Antipathes spiralis*, consisting of concentric laminæ of brown horny material. In the centre is a small opening, surrounded by a margin of a richer brown colour than the other parts, and from it radii of considerable size are given off; these in some cases project from the outer surface of the skeleton in the form of small spines. A portion of this preparation is represented in Plate XIII. fig. 20.

b. *Skeleton composed of horny material, in which Calcareous Spicula are imbedded.*

A r 5. A transverse section of a Polypidom of *Alcyonium digitatum*, exhibiting the divided areas of many large aquiferous tubes; these have strong horny coats, and are sometimes filled with a jelly-like matter. The tissue between the tubes is composed of horny filaments, and a transparent gelatinous tissue, in which last are imbedded numerous calcareous spicula of various shapes and sizes; some of them are nearly straight, others

curved, and not a few present a crucial appearance; all are branched and more or less tuberculated. Three of these spicula are represented in Plate XIII. fig. 7.

A r 6. Spicula obtained from the same *Alcyonium* by boiling a thin slice of the polypidom in caustic potash; they are of a white colour, and present many varieties of forms, the most common being of small size, and in shape like a cross; others also occur that are much larger, and have as many as four or five lateral branches. All the specimens are more or less tuberculated.

A r 7. A transverse section of an *Alcyonium* from the Navigators' Islands, exhibiting a framework of horny fibres situated around the walls of the large aquiferous tubes. In the gelatinous matter, forming the great mass of the zoophyte, may be observed calcareous spicula of large size, almost all of which are straight and covered with rounded tubercles, arranged principally in an annular form.

Presented by Captain Sir E. Home, Bart., R.N.

A r 8. Spicula obtained from the same *Alcyonium*; they are of white colour, rarely branched, but covered with two or more rows of spinous tubercles; some few specimens are occasionally met with in which may be seen the commencement of the formation of four or more branches; in these there are radii extending from a centre into each of the branches. The average length of one of these spicula is $\frac{1}{120}$th, and the breadth $\frac{1}{400}$th of an inch.

Presented by Captain Sir E. Home, Bart., R.N.

A r 9. A transverse section of the stem of *Gorgonia Americana*, consisting of concentric laminæ of horny material, in which are imbedded numerous calcareous spicula of irregular figure, being more like masses of crystals than the spicula found in the crust of the same specimen; these are deposited in concentric layers, and are so numerous, that in a part not $\frac{1}{8}$th of an inch in diameter, there are no less than twenty rings. A portion of this preparation is represented in Plate XIII. fig. 19.

A r 10. A transverse section of the stem of a large red Gorgonia, *Melitæa ochracea*, consisting principally of carbonate of lime. This stem is not solid

as the one last described, but has numerous large canals running through it. Some parts of the section are red, others yellow, and when examined with a power of 100 diameters, the greater portion of the red will be found to exhibit little or no structure; but the yellow, which is softer than the red, contains numerous spicula, all of a yellow colour; they are of small size, and deposited in a light-coloured horny matrix; some portions of the red however which join the yellow also contain spicula.

A r 11. A transverse section of the stem of a small red Gorgonia, *Gorgonia petechialis*, in which the spicula are very abundant, but the horny matter small in quantity. The outer margin is of a dark red colour, and is composed of a mass of large flattened angular spicula, closely aggregated together; the internal portion is also composed of spicula, but these are of small size, and arranged in bundles so as to form a fibrous network around a series of pores or canals. A portion of this preparation is represented in Plate XIII. fig. 1; at *a* are shown the large red spicula of the margin, and at *b* the smaller ones arranged in bundles.

A r 12. Spicula obtained by boiling a portion of the stem of the same *Gorgonia* in caustic potash. They are principally of two kinds, one large, angular, flattened, and of a red colour, the other small, thin, slightly curved, and having generally one tubercle in the centre only; many other varieties are met with, the most common being a spiculum of larger size than the curved one, but having tubercles only on one side. The first kind, or that of the margin, is represented at *c* in Plate XIII. fig. 1, the second at *d*, and the third at *e*.

c. *Skeleton composed of Horn and Calcareous Matter, the latter not in the form of Spicula.*

A r 13. A vertical section of a portion of the stem of *Isis Hippuris*, including both the horny and calcareous matter; the former is of a brown colour without spicula, the latter is composed of a dense mass of carbonate with a slight admixture of phosphate of lime, without any trace of radiated, cellular or other structure. An abundance of spicula are found in this animal, but they are confined to the crust.

d. *Skeleton composed of Calcareous Matter only.*

A r 14. A transverse section of the stem of *Corallium rubrum*, or red coral of commerce; it consists of a series of undulating layers of calcareous matter of a red colour, exhibiting no trace of cellular structure, but being rather of a crystalline nature.

A r 15. A transverse section of a small circular branch of a Nullipore, *Millepora informis*, exhibiting little or no structure except on one edge: this presents hexagonal cells with radii around the central pores. A portion of this preparation is represented in Plate XIII. fig. 23.

A r 16. A transverse section of a branch of a Madrepore, *Oculina virginea*, consisting of a series of zones exhibiting somewhat of a crystalline structure.

A r 17. Thin sections of a Tubipore, *Tubipora musica*, exhibiting numerous canals in its substance; the calcareous matter is of a red colour, but presents no cellular or crystalline structure.

A r 18. A transverse section of a branch of a Myriapore, *Nullipora alciformis*, in which may be seen a distinctly reticulated tissue, the diameter of each of the reticulations being about $\frac{1}{1300}$th of an inch. This structure resembles that of the shell of an Echinus, and is represented in Plate XIII. fig. 12.

A r 19. A portion of the central axis or skeleton of *Virgularia mirabilis*, composed of brittle calcareous matter; when examined with a power of 200 linear, a series of minute, wavy canals, like the tubuli of dentine, are visible in its interior; they all open on the free surface, and pass in curved lines towards the centre of the stem, which is more opaque than the rest. The intertubular tissue presents longitudinal striæ, and when the lime is removed by acid, the residual animal matter is of a fibrous nature. A small portion of this specimen is represented in Plate XIII. fig. 11.

A r 20. A transverse section of the bony axis or skeleton of *Pavonaria quadrangularis*; it is of a square figure with concave margins, and consists of a series of laminæ of fibro-calcareous matter, arranged around a central cross; the outer portion or crust is so extremely hard, that it can scarcely be cut with a knife. If the calcareous matter be removed, a distinctly fibrous structure remains.

Presented by Professor Edward Forbes, F.R.S.

A r 21. A transverse section of the bony axis or skeleton of a Sea-pen, *Pennatula phosphorea*, which, like the specimen last described, consists of a mass of fibro-calcareous matter, but instead of being square is cylindrical, and to the naked eye appears to be composed of a series of concentric laminæ. When examined with a power of 100 linear, the outer margin or crust is found to be of a fibrous nature, the fibres taking a vertical direction; but the central portion, which is more dense than the rest, is made up of a cellular structure; the cells in most cases appearing to be composed entirely of earthy matter.

e. *Spicula occurring in the fleshy covering of Zoophytes having a skeleton composed of Horny or Calcareous Matter, or of both combined.*

A r 22. Calcareous spicula obtained from a species of *Alcyonium* from New Zealand; they are of a dark brown colour, and somewhat in shape like a cucumber, having all parts of their outer surface studded with conical tubercles; some of them exceed $\frac{1}{8}$th of an inch in length, others are as small as $\frac{1}{200}$th. Three specimens are represented in Plate XIII. fig. 6.

Presented by Captain Sir E. Home, Bart., R.N.

A r 23. A portion of the outer covering or crust of *Xenia florida* from the Philippine Islands, containing numerous acerate calcareous spicula of very large size, and of a rich brown colour, some of them even exceeding $\frac{1}{4}$th of an inch in length, and all covered with conical tubercles. These spicula, like those of sponges, are not only covered by an animal membrane, but the calcareous matter is also deposited in an animal matrix, which can be readily shown by the aid of acid. The largest spicula are found projecting from the soft parts in the form of spines, and readily enter the fingers if the animal be not carefully handled.

Presented by Hugh Cuming, Esq.

A r 24. A portion of the outer covering of another species of *Xenia*, provided with numerous spicula of a yellow colour, and smaller size than those in the preceding specimen, but occupying the same situations. Those projecting from the surface are particularly large and sharp-pointed.

Presented by Hugh Cuming, Esq.

A r 25. A portion of the flesh from the lower part of the stalk of *Pavonaria quadrangularis*, containing numerous small oval-shaped spicula, having their long axes in the direction of that of the central calcareous stem.

Presented by Professor Edward Forbes, F.R.S.

A r 26. Spicula obtained from the flesh of the lower part of the stalk of the same Zoophyte; they are of an oval figure, somewhat flattened, and exhibit traces of a radiated structure. A few specimens are represented in Plate XIII. fig. 13; their average length is $\frac{1}{160}$th of an inch.

Presented by Professor E. Forbes, F.R.S.

A r 27. Spicula obtained from the flesh of the upper part of the stalk of the same Zoophyte; they occur around the margin of the sheath into which the polypi retract themselves and form triangular bristling projections alternating with the polypi. These spicula differ from those above described in being longer, and having both ends pointed.

Presented by Professor E. Forbes, F.R.S.

A r 28. Spicula obtained from the flesh of the kidney-shaped Sea-pen, *Renilla Americana*; they are of cylindrical figure, $\frac{1}{70}$th of an inch in the long by $\frac{1}{800}$th in the short diameter, and being somewhat twisted they appear, like those of sponges, to be provided with a central canal. In colour they are of a rich purple, and are found principally upon the outer surface of the Zoophyte. A characteristic spiculum is represented in Plate XIII. fig. 24.

A r 29. Spicula obtained from the outer surface of the rachis of a large Sea-pen, *Pennatula grisea*; they are of large size, sometimes exceeding half an inch in length, and occur in bundles. Some specimens are sharp at both ends, others are sharp at one end and expanded at the other like the feather of an arrow. All exhibit a distinctly fibrous structure, and appear very like the large bristles on the sides of some species of *Aphrodita*. Other spicula occur in the back part of the rachis; these are of minute size, pointed at both ends, and arranged so as to form large bundles.

A r 30. Spicula obtained from the animal matter in the lower part of the stem of the same Sea-pen; they are of cylindrical figure, having both ends

terminating hemispherically, but exhibit no trace of tubercular or other structure; on an average they measure $\frac{1}{130}$th of an inch in the long, by $\frac{1}{800}$th in the short diameter. Like those in the *Pavonia*, they appear to be confined to the lower portion of the stem. Spicula of the same shape, but not so decidedly calcareous, are to be found in a corresponding situation in a smaller British species, *P. phosphorea*.

A r 31. Spicula obtained from the thick fleshy crust of *Isis Hippuris*; they are mostly of a quadrate or clavate figure covered with large nodulated tubercles. Three of the most characteristic specimens are represented in Plate XIII. fig. 9.

A r 32. Spicula obtained from the fleshy crust of *Isis ochracea*; they are principally of two kinds, one elongated and tubercular, found in the outer part of the crust; the other cylindrical and nearly of uniform diameter throughout without any tubercles; some of these last however have a slight projection in the centre, and form the interior framework of the crust.

A r 33. Spicula obtained from the fleshy crust of *Gorgonia umbraculum*; they may be divided into two principal varieties; one found in the crust, of large stellate angular figure and rich brown colour; the other much smaller and covered with nodulated tubercles. The two kinds are represented in Plate XIII. fig. 2, the first being shown at *a*, the second at *b*.

A r 34. Spicula obtained from the fleshy crust of *Gorgonia Americana*, some of which are short, very regular in shape, and all have nearly the same number of tubercles; others are elongated and irregular in figure, being without tubercles; many of these last very much resemble crystals, and are of the same nature as those described in Preparation A r 9, as occurring in the horny stem of the same *Gorgonia*. In colour they are light brown, but many of them are nearly black in the centre.

A r 35. Spicula obtained from the fleshy crust of *Gorgonia juncea*; they are of two colours, one a beautiful yellow, and the other an equally beautiful lake; the latter present the greatest variety of form, being either short and having two rows of tubercles, or else thinner and rather more elon-

gated and provided with four or more rows of the same tubercles. The former, or yellow kind, are in shape exactly like the short red variety, and differ from them only in colour.

A r 36. Spicula obtained from the fleshy matter of an unknown species of *Gorgonia*; they are of large size, and either simple or bi- or tri-radiate. In colour they are either white or beautiful lake, both kinds being remarkable for the great number of their tubercles, which are much smaller in size than those on any of the forms of spicula before described.

A r 37. Spicula obtained from the outer crust of *Gorgonia elongata*; they are of various forms, the most common being the elongated, which is covered with tubercles arranged in rings; the most peculiar variety belonging to the specimen is represented in Plate XIII. fig. 5, being slightly arched, and having tubercles on one side only. Their colour varies from a dull lake to a dirty white.

A r 38. Spicula obtained from the thick crust of *Gorgonia flammea*; they are of a dirty white colour, some specimens being even black in the centre. The shape of many of them resembles that of *Isis Hippuris* and *I. ochracea*; but all the tubercles, which are very numerous, have the common character of being covered with thick angular sharp-pointed spines.

A r 39. Spicula obtained from the fleshy crust of *Muricea elongata*; they are of a yellowish-brown colour, and of peculiar figure, being somewhat like that of a club-shaped spine of some of the *Echinidæ*; one end, or that which for the sake of distinction may be called the base, is covered with short sharp-pointed tubercles; the other, or apex, is considerably expanded, and is covered with spines, the free extremities of which all point in one direction. Four of these spicula are represented in Plate XIII. fig. 3.

A r 40. Spicula of the fleshy crust of an unknown species of *Gorgonia*, the greater portion of which present the usual tuberculated figure, as shown in Plate XIII. fig. 4 *b*; but amongst them may be seen others of a shape somewhat like a decanter, and to a certain extent resembling those in the preceding preparation, being expanded at the apex and small at the

base; around the latter may be seen short angular spines, but around the former are three rows of smaller spines arranged one above the other, like the scales in the hair of many of the Bat tribe; four specimens are represented at *a* in fig. 4.

A r 41. Spicula of the fleshy crust of an unknown species of *Gorgonia*, some of which are remarkable for their large size, being upwards of $\frac{1}{8}$th of an inch in length, whilst others are of the shape of a flask or decanter, being very small at one end and large and expanded at the other; this latter part being composed of four or more plates or laminæ arranged nearly at right angles to each other, the margin of each plate being notched or indented; the spicula are of a white colour, many of the larger varieties are also white, but others are more or less crimson. Some spicula of the most common forms, viz. sharp at both ends and covered with rows of tubercles, also occur in this preparation, but all the largest specimens are completely covered with small angular tubercles.

f. *Spicula composed of horny matter.*

A r 42. Spicula of a horny nature obtained from the tubercles of an *Actinia*, *Actinia mesembryanthemum*; they are of minute size, some being cylindrical, others acerate in shape. Spicula were first noticed by Prof. J. W. Bailey, in the tentacula of a large species of *Actinia*, *A. marginata*, found at Boston, U.S.; he supposed them to be siliceous; similar spicula having been met with in a British species, *A. mesembryanthemum*, were tested by Dr. Johnston, and found to be destroyed by burning, but not acted on by the weaker acids; he therefore supposed them to be of a horny nature. Four specimens of the acerate variety are represented in Plate XIV. fig. 13. *Presented by M. S. Legg, Esq.*

Subseries V. *Skeleton of Acalephæ.*

The animals composing this class, unlike the Polypiphera, are not attached to rocks, but swim freely in the waters of the ocean; they are generally of a soft gelatinous nature, and with very few exceptions are not provided with any kind of hard tissue that can be called a skeleton; from their peculiar appearance, many of them have obtained the name of Sea-jelly or Jelly Fishes, whilst others,

from their stinging propensities, have been termed Sea-nettles, hence the word Acalephæ from ἀκαλήφη, a Nettle. The means of progression employed by these remarkable animals has enabled zoologists to arrange them in groups. Some kinds, as the *Medusæ*, are kept above the surface of the water by a circular gelatinous mass resembling an umbrella, by the frequent expansion and contraction of which, progression is effected; others, as the *Beroë*, are provided with ciliated arms to answer the same purpose; whilst others, as the *Physalidæ*, have swimming-bladders capable of being dilated or contracted at the will of the animals, so that they can sink or swim at pleasure; one species, known as the Portuguese man-of-war, has a single large bladder, which, when filled, rises above the surface and serves as a sail, whereby the animal is carried over the waves with some rapidity. A modification of this plan is found in certain species of another group; for instance, *Velella*, in which a portion of horny matter supporting a delicate expanded membrane, is elevated above the water in the form of a sail. In this animal and the *Porpita*, we have the best representatives of the skeleton of the *Acalephæ*.

A s 1. A horizontal and vertical plate of transparent horny matter, forming the skeleton of *Velella limbosa*. The former is of an oval figure, concave below, and marked with concentric lines of growth, whilst the latter is not only much thinner than the horizontal one, but is firmly attached to it in a rectangular position, and rises above it in the form of a crest. When examined with a power of 100 diameters, neither of the plates present any trace of cells or reticulations; the concentric lines, which are even visible to the naked eye, are the only parts that can be said to exhibit any variety in structure. Some specimens of this animal are occasionally met with as small as $\frac{1}{8}$th of an inch, whilst others even exceed two inches in length.

A s 2. A portion of the horizontal plate of another *Velella*, in which broad concentric lines may be plainly seen; in certain lights there is a faint indication of a delicate fibrous structure, especially near the outer edge.

A s 3. A portion of the vertical plate of the same animal; it is exceedingly thin, and exhibits only a faint indication of the concentric lines, but in some

parts a slight fibrous structure, similar to that in the preceding specimen, is very evident.

A s 4. A flat circular horny disc forming the skeleton of *Porpita gigantea*. To the naked eye it exhibits both radiating and concentric markings, and when examined with a power of 40 diameters, its upper surface is found to be furrowed, and two rows of small projecting spines occur upon the ridges between the furrows, the ridges being the radiating fibres above noticed; the under surface, or that to which the greater portion of the soft parts of the animal are attached, is more deeply furrowed, and plicæ or folds of the mantle fit accurately into the furrows, from which they can easily be removed by the application of a gentle force. The concentric markings have in all cases small scalloped edges; they occur at certain regular intervals, and are so many indications of the lines of growth. In the centre there is a circular depression, and between its circumference and that of the first concentric marking, there are eight flattened radii. If the under surface be examined with a power of 100 linear, the ridges will all be found to have small jointed tubular processes like hairs projecting from them; the precise office these processes perform cannot be here stated, as the soft parts were separated from the skeleton before it was submitted to examination. In no part of this horny tissue is there any trace of a cellular or reticular structure.

A s 5. A vertical section of the horny skeleton of another species of *Porpita*, about one inch in diameter, composed of a series of membranous folds, so arranged as to form both radiating and concentric markings; in some cases the folds are so small as to present an appearance of being made up of a fibrous tissue. In one part of the section may be seen a series of oval bodies, which under certain lights resemble perforations, these are the bases of the spines which were noticed as occurring on the upper surface of the horny disc.

Subseries VI. *Skeleton of Echinodermata.*

The skeleton in these animals generally consists of an assemblage of plates or joints of calcareous matter, arranged in the form of an external crust or shell, covered in most cases with large projecting spines.

The minute structure of the skeleton presents more or less of a reticulated character, and the solid parts are usually composed of a series of superimposed laminæ, the openings or areolæ in one layer being always placed over the solid cell-walls of the layer beneath it; in some cases the layers are in contact, but in others they are separated by minute vertical pillars. This character is constant in all the shells of the *Echinidæ* and *Asteriadæ*, the reticulate structure being found in every part of the skeleton, however dense it may at first sight appear. The projecting spines of these two classes of animals, as well as the joints of the *Crinoideæ*, present the same kind of structure. As in the Sponges and Corals generally, the animal and earthy matter are intimately blended, but the quantity of the former is rather small in comparison with that of the latter, and when the calcareous portion of the skeleton has been dissolved in very weak acid, a fibrous structure like that of areolar tissue is left behind.

a. *Skeleton in the form of an external crust or shell.*

A t 1. A horizontal section of the outer crust or shell of a Star-fish, *Asterias rubens*, consisting of two or more layers of calcareous matter presenting an areolar or reticulate structure, the areolæ being in some cases either of a round or oblong figure, and the framework exceedingly thick. On the edges, as well as in many of the thinner parts, the remains of the small pillars separating two or more layers from each other are readily seen.

A t 2. A portion of the shell of a large Star-fish, *Asterias echinites*, consisting entirely of a reticulated structure, the reticulations being either of a square or oblong figure, as shown in Plate XIII. fig. 16, and the calcareous matter composing them being more or less rounded. All parts of the skeleton of this animal, however large or dense, were made up of the same kind of structure.

A t 3. A portion of a fossil Star-fish, *Pentagonaster*, from the chalk; it consists

of small more or less square masses of carbonate of lime, each of which, when made sufficiently thin, exhibits a reticulated structure, and appears to be composed of two sets of parallel lines or bands of granular matter, arranged at an angle of 75° with each other, and forming between them either oval or square areolæ. At first sight, this structure very much resembles the corneal layer of the eye of a Cray-fish. A small portion of this preparation is represented in Plate XIII. fig. 8.

A t 4. A horizontal section of the shell of an *Echinus*, *E. esculentus*; it consists entirely of superimposed laminæ, all exhibiting a reticulated structure, the reticulations in each being so arranged that the openings in one layer are placed over the solid parts of the layer both above and beneath it, and there being also small circular supports or pillars between each of the layers, which are indicated in the section by small circular dots. The diameter of the reticulations varies considerably, being from $\frac{1}{300}$th to $\frac{1}{2000}$th of an inch. A portion of this preparation is represented in Plate XIV. fig. 2.

A t 5. A horizontal section of the shell of a *Spatangus*, exhibiting a reticulate structure somewhat like that of the preceding preparation, but all the openings or areolæ are of circular figure, and nearly uniform in size; the surrounding framework is very strong, in some instances as broad as the areolæ themselves. The pillars separating the layers are large and very conspicuous. A portion of this specimen is represented in Plate XIV. fig. 3.

A t 6. Portions of the shell of an *Echinoderm*, found in some Ichaboe guano, consisting of small detached pieces of more or less regular figure, having indented margins and perforations of various sizes; in nearly every specimen the small projecting pillars are visible. One of the most characteristic specimens is represented in Plate XIII. fig. 15.

Presented by Mr. J. W. Bond.

A t 7. A vertical section of the shell of an *Echinus*, made through one of the large tubercles to which the spines are attached; it exhibits two or more kinds of reticulated structure; the first or most common kind composes

nearly the entire thickness of the shell, and is found as a curved band extending from one side of the specimen to the other; above this, in the middle line, is a very coarse network, also curved, which is formed by branching vertical columns, these support a very dense tissue composed of minute areolæ of the same kind as the tubercle itself, which last is attached to its upper surface, and may be known by its circular figure, and by a dark line surrounding its lower border. On either side of the dense tissue supporting the tubercle may be seen a band of fine reticular structure, having its areolæ arranged in a longitudinal direction; above this is a similar tissue, having its areolæ arranged at right angles to the last; this has a convex margin, and forms the semicircular prominence upon which the tubercle is situated. This preparation is represented in Plate XIV. fig. 4.

A t 8. A horizontal section of one of the calcareous plates situated around the mouth of a Holothuria, *Cucumaria frondosa*; it consists entirely of a reticulated structure resembling that of the Star-fish described in Preparation A t 2, but the areolæ are larger and less regular, as represented in Plate XIV. fig. 17. A small calcareous disc, as shown in fig. 12, is also to be found at the extremity of each of the large tentacula of this animal*.

A t 9. A portion of the shell of an *Ophiura*, *Ophiura texturata*, exhibiting a minutely reticulated structure, somewhat like that found in the tubercles of the shells of Echini, or in the dense part composing the base of the spines of the same animals. The openings or areolæ in the reticulations are of circular figure, and on an average about $\frac{1}{2000}$th of an inch in diameter; they are generally arranged in parallel lines following the direction of the arms of the specimen from which the preparation was taken.

A t 10. A portion of the outer crust of a *Comatula*, *Alecto glacialis*, consisting of the same kind of reticulated tissue as that found in the shells of the Echini, and like them also consisting of several laminæ, separated from each other by short strong pillars. The areolæ or openings of the reticula-

* Appendix D.

tions are mostly of an oval figure and of variable size, and are much less numerous than in any of the other kinds yet described.

A t 11. A transverse section of the stem of *Pentacrinus Caput Medusæ*, consisting of a reticulated structure, like that found in some of the preceding preparations ; in the centre is a small circular opening, and from its margin five oval arms radiate, these arms are not distinct structures, but their appearance is produced by the areolæ of the reticulations composing them being different in size from those in all other parts of the surface of the preparation. The arms are constant in all the joints of this recent Pentacrinite, and are very visible to the naked eye. The entire specimen, slightly enlarged, is represented in Plate XV. fig. 1, and a segment of the same more highly magnified, including one of the arms, is shown at fig. 2*.

A t 12. A transverse section of the stem of a fossil Encrinite, *Encrinites moniliformis*, exhibiting a minutely reticulated structure ; in the centre there is a diamond-shaped opening about $\frac{1}{16}$th of an inch in diameter, around this the areolæ are arranged in a series of rings, but there are no arms, as in the Pentacrinite. A segment of this preparation is represented in Plate XV. fig. 4.

b. *Spines of Echinodermata*†.

The spines are situated on the external surface of the shell, they are generally of a conical figure, and in the Echini, with very few exceptions, are articulated to the tubercles by a ball-and-socket-joint. The simplest spines are those found in the larger kinds of Star-fishes ; they consist entirely of a reticulated tissue, like that found in the shell of the same animal, the cells generally speaking being of the same size in the centre as at the circumference, as shown in Plate XIV. fig. 1. The spines of the Echini, on the contrary, are rather more complicated in their structure, their mode of growth is by the addition of new layers to their external surface ; the outer part of each layer being always provided with a series of ribs or pillars, which, according to their size and number, give to this surface a grooved or fluted appearance ; when a thin transverse section of one of these

* For other examples see Appendix E.

† For our knowledge of the intimate structure of these appendages to the skeleton of Echinodermata, we are mainly indebted to the labours of Dr. W. B. Carpenter, an account of whose valuable researches will be found in the Reports of the British Association for 1847.

spines is examined with the naked eye, it appears to be made up of a series of concentric layers, varying considerably in number, not, however, with the size of the spine, but with the distance from the base at which the section was made; when a section taken from the middle of the spine is examined with a power of 50 diameters, it will be seen that the centre is occupied by a reticulated structure: around the margin of this, as shown in Plate XIV. fig. 11, may be observed a series of small structureless spots arranged at equal distances apart; these are the pillars before alluded to, and indicate the external surface of the first layer deposited; passing towards the margin, other rows of larger pillars may be seen, and if the margin be perfect the sections of the pillars will give it a beautiful indented appearance, as shown at *a a* in Plate XIV. fig. 11; all the other parts of the section are occupied with the usual reticulated tissue; in the greater number of spines, the sections of the pillars present no structure, in others they exhibit a series of concentric rings, and in those of the *Cidaridæ*, the entire set of pillars may be consolidated into one thick layer; in this, as shown in Plate XIV. fig. 16, large radiating tubes of uniform diameter are generally visible. When a vertical section of an *Echinus* spine is examined, it will be found to be composed of a series of cones placed one over the other, as shown in Plate XIV. fig. 10, the outer margin of each cone being formed by the series of pillars before alluded to; it will now be evident that a transverse section made near the base of the spine, will include more concentric rings than one made nearer the apex, and it will also be seen why so great a variety of apparently different sections can be made from the same spine. In the genus *Echinus*, the number of cones is considerable, but in that of *Cidaris* there are seldom more than one or two, so that from such spines transverse sections may be made having no concentric rings, and in which only the external row of pillars may be seen, as shown in Plate XIV. fig. 16. The above description may be said to be characteristic of spines in general, though many examples will be found in which these rules may, at first sight, appear to have been departed from; but on more careful examination and consideration of the exact distance from the base from which the section was taken, all will be found to be constructed on a nearly uniform plan.

A t 13. A transverse section of a Spine of a large Star-fish, *Asterias echinites*; it presents a radiated reticulated structure, for the most part very similar

to that of the shell of the same animal; but when carefully examined, the central portion will be found to differ from the other parts in having certain very large reticulations, or even canals, surrounded by a network of smaller ones, there being about twelve in this section. All the other parts of the centre are composed of reticulations much coarser than those nearer the margin. One other point of interest connected with this specimen, is the small size and rounded figure of the calcareous framework of all the reticulations, so different from that of the spines of the *Echinidæ*. A segment of this transverse section is represented in Plate XIV. fig. 1. The outside of the spine was surrounded by a brown horny membrane, a part of which is still visible on the circumference.

A t 14. A transverse section of a Spine of a Star-fish of the genus *Astropecten*, of much firmer consistence than the last described specimen, but like it composed entirely of a reticulated structure. In the centre, there is a spot about $\frac{1}{50}$th of an inch in diameter, occupied by reticulations arranged without much order; all the other parts are occupied by reticulations disposed in a radiated form, the size of the cells increasing gradually from the centre to the circumference. This section very much resembles that of a spine of an *Echinus*: a segment of it is represented in Plate XIV. fig. 2.

A t 15. A transverse section of an oval Spine of an Echinus, *Echinus atratus*, taken from near the bottom; it is of a purple colour, and exhibits no less than seven concentric lines or rings of growth, all of which are well marked. The reticulations in the centre, although of small size, are larger than those in any other part of the specimen; from the first ring of pillars, radii extend to the circumference: they are so close, that the reticulated structure between them cannot be well seen.

A t 16. A transverse section of the same Spine, taken from about the middle of the specimen; it exhibits only four rings of growth, but in all other respects is similar in structure to that of the preceding preparation.

A t 17. A transverse section of the same Spine, taken near the top; the spine at this part is more expanded than at the base, and the section in consequence is rather more than twice as long as it is broad. Only one ring of

pillars is to be seen, and this is situated at some considerable distance from the centre. The general structure of the specimen resembles that of the two preceding.

A t 18. A transverse section of the same Spine, taken at the top, being rather broader than, but not so long as, the preceding specimen; it exhibits only a single ring of pillars, and this is more plainly marked on one side than on the other; the same thing occurs in the pillars on the margin. The radiated structure is still to be made out, although the reticulations are so small and numerous as almost to destroy it.

A t 19. A transverse section of one of the flattened plates or spines found on the convex surface of the same *Echinus*; it is of a hexagonal figure, and its reticulated structure is more coarse than that of the long spines. There is no trace of pillars, the lines of growth being indicated by upwards of seven purple rings.

A t 20. Another section of the same Spine, which has been rendered transparent by grinding its under surface only, the outer one being left untouched; it exhibits a structure perfectly distinct from that of the last described specimen. When the upper surface is brought into focus, nothing is seen but a series of small oval or circular areolæ or perforations, arranged somewhat in a hexagonal form; when however a deeper portion of the specimen is in focus, a distinct hexagonal framework inclosing larger areolæ becomes visible, the framework being composed of a structureless material. The size of the hexagons is precisely similar to that marked out by the perforations above alluded to. The colour of the section is a rich purple. A portion of this preparation is represented in Plate XIV. fig. 7; at *a* the perforations are shown, and at *b* the hexagonal network beneath them.

A t 21. A transverse section of a Spine of a large Echinus, *E. trigonarius*, taken from near the base; it consists of a central red portion composed of a series of large hexagonal reticulations, like those occurring in the preceding preparation; having around its margin a row of small pillars, which appear to send radiated prolongations into the central reticulations; between these radii is a reticulated structure of the ordinary kind.

This character is maintained throughout all the other parts of the section, but with a slight difference, viz. that a series of minute transverse bands pass across the radii and connect the reticulations together. In this specimen there are fourteen rows of pillars, those nearest the centre being of a reddish-brown, the others of a green colour.

A t 22. A transverse section of the same Spine, taken from near the apex; it is of a peculiar triangular figure, and exhibits only seven rows of pillars, each one being also of a more or less triangular shape. The disposition of the pillars, their radiated prolongations, and the transverse bands connecting the reticulations are well displayed.

A t 23. A transverse section of a small conical green Spine of an undescribed species of *Echinus*, taken from the base, and remarkable for the large size and great number of its pillars. The centre is composed of a coarse areolar network; around this is a band of the ordinary reticulated tissue surrounded by a row of pillars, then another narrower band of reticulated tissue, then another row of pillars, and so on until six rows of pillars are found; each band of reticulated tissue becomes narrower and narrower as the pillars increase in size, so that close to the margin there is no band at all, and no reticulated tissue, except that existing in the form of radii between the pillars. A portion of this preparation is represented in Plate XIV. fig. 11.

A t 24. A transverse section of the same Spine, taken from about the middle. The centre is occupied by a coarse areolar structure; the first band of reticulations occupies about two-thirds of the breadth of the entire specimen; on its outer margin are three rows of large pillars, exhibiting only partial traces of reticulated bands between them.

A t 25. A transverse section of the same Spine, taken from near the apex. The coarse areolar structure is present in the centre, but the band of reticulations around it is so extensive as to extend in the form of radii as far as the margin, the intervals between the radii being occupied by a single row of large pillars, continuations of which also proceed in the form of radii from the margin to the cells in the centre.

A t 26. A transverse section of a Spine of an undescribed species of *Echinus*, taken from near the base; in structure it very much resembles Preparation A t 23, but in size it is much larger. The centre is occupied by a few coarse areolæ, around which is a band of radiated reticular structure, having a row of pillars on its outer margin; then another radiated band and a row of pillars, both of larger size than the last; two more bands occur between this and the margin of the spine, but they are very narrow. The chief point of interest in this specimen is the fact that all parts of the pillars are not composed of structureless material, but are occasionally traversed by reticulated structure: this is very evident in many parts of the preparation; if some of the larger pillars on the margin be examined, they will be found to be covered with a reticulated tissue, quite different from that occurring in any other part of the surface. There is also a difference in the arrangement of the radiated reticulations; in some cases they extend from the first row of pillars to the circumference, in others they are divided into zones: the latter is the more common disposition. A segment of this section is represented in Plate XV. fig. 9.

A t 27. A transverse section of the same Spine, taken from near the apex; it exhibits only one row of pillars: these are on the margin; the reticulated band in the form of radii also extends from the areolæ in the centre as far as the margin. The pillars are wedge-shaped, convex on their outer surface, which gives the edge an indented or beaded appearance, and are continued from the margin as far inwards as the areolæ in the centre; small transverse reticulated bands pass over them and connect the radiated reticulations together.

A t 28. A transverse section of a small conical purple Spine of an undescribed species of *Echinus*, taken from near the base. The centre is occupied by a group of large areolæ, having around them a zone of radiated reticulations of a rich purple colour: this is surrounded by a zone of small pillars, each having a perforation which appears as a white spot between them; the other portion of the spine is made up of four zones of radiated reticulations of a brown colour, each surrounded by its zone of pillars, all having perforations between them. The margin is composed of pillars, and it

will be then seen that the perforations are so large as to give to the pillars the form of rounded tubercles.

A t 29. A transverse section of the same Spine, taken from near the apex. The areolæ in the centre are well shown, and from their outer margin radii extend nearly as far as the circumference; here a row of pillars having their characteristic perforations are found; between this and the margin there is another row not quite complete, and on the margin itself traces of a third, the two last having hardly any reticulated structure between them. This spine is of a beautiful purple colour in all parts except the pillars, which are light brown.

A t 30. A transverse section of a small conical purple Spine of an undescribed species of *Echinus*, taken from near the base; it exhibits on a small scale an arrangement of parts precisely similar to that of Preparation A t 23, the only perceptible difference being in the structure of the pillars, all of which present a series of minute curved lines; these are not however lines of growth coinciding with those in other parts of the spine, but each pillar has its own peculiar set.

A t 31. A transverse section of a Spine of an *Echinus*, taken from the middle; it exhibits a central radiated structure, and four rows of pillars; these latter, however, are remarkable for their beautiful purple colour.

Presented by Dr. W. B. Carpenter, F.R.S.

A t 32. A transverse section of a brown Spine of an *Echinus* of unknown species, taken from near the base; it exhibits eight rows of angular pillars, separated from each other by a peculiar reticulated tissue composed of a delicate framework, presenting no appearance of radiated structure. A segment of this section is represented in Plate XIV. fig. 15.

Presented by the Rev. James Landy Brown.

A t 33. A transverse section of the Spine of *Echinus mammillatus*, taken from near the base; it presents one or two peculiarities worthy of notice. In the centre there is a coarse areolar tissue of a dark blue or purple colour, surrounded by two or three rings of a richer tint; between

these and the margin there are five others, each of a tint different from that of the other portions of the spine. The reticulated structure is very close, and the cells become smaller and smaller from the centre towards the circumference: in this part they are so fine as not to be distinctly recognized.

A t 34. A transverse section of the same Spine, taken from a spot rather nearer the apex; it exhibits in the centre a beautiful network of areolar tissue of a pink colour; between this and the margin are eleven rows of pillars; the margin itself is composed of the same kind of small reticulated tissue as that described in the last preparation.

A t 35. A vertical section of a Spine of the same *Echinus*, in which the general arrangement of the principal structures may be seen with the naked eye. This specimen is represented in Plate XIV. fig. 10; it will be found that the base consists of a whiter and more compact tissue than the other parts of the specimen, and that the bulk of the spine is formed by seven cones fitting one over the other, each being indicated by a white structureless line, within which is a streak of purple colour; running up through the middle may also be observed a diverging column of reticulated tissue of a different structure from that composing the series of cones. When the specimen is examined with a power of at least 40 diameters, the base *a* will be seen to be composed of a very dense tissue, like that before described in Preparations A t 33 and 34, as occurring on the margin of a spine, and the walls of the cones will also be seen to be composed of a structureless tissue; the central column, before alluded to, consists of a series of large reticulations arranged nearly in parallel lines. The reticulations of the cones are much smaller than those of the central column, and their direction is principally radiated. It will be evident from this Preparation, that a section made near the base, as, for instance, through the line *b c*, will contain more concentric rings than one made through *d e*, and that one made through *f g* ought to exhibit no ring at all, except that surrounding the central column.

A t 36. A transverse section of a small conical Spine of an unknown species of

Echinus, taken from near the base; it consists of little else than concentric rings of large pillars, except the margin, which is composed of a broad zone of densely reticulated tissue, like that described in Preparations A t 33, 34. The edge of the specimen has the densest reticulations, and presents a series of indentations; these correspond in number with the radii running between the pillars.

A t 37. A transverse section of a Spine of an unknown species of *Echinus*, taken from the base; it forms an object of great beauty, being remarkable for the number of its rows of pillars, and for the close reticulations of its margin, which resemble those of the preceding specimen.

Presented by the Rev. James Landy Brown.

A t 38. A transverse section of a large Spine of *Echinus coronatus*, taken from near the base; it exhibits a coarse reticulated structure in its centre, around which is a zone of finer cells arranged in a radiated form, having a row of pillars on its outer margin; between this and the circumference of the specimen are three other zones, each having its margin of pillars; as in some of the preceding preparations, each pillar is prolonged in the form of a radius from the outer margin to the mass of large cells in the centre. This specimen measures $\frac{3}{8}$ths of an inch in diameter.

A t 39. A transverse section of the same Spine, taken from near the apex; it differs from the preceding specimen in having the mass of coarse cells in the centre much larger, and the distance between them and the first row of pillars nearly double the extent of that in the preceding specimen; between this row of pillars and the circumference of the spine, a distance less than $\frac{1}{8}$th of an inch, are no fewer than five other rows of pillars, each separated by a zone of reticulated tissue. This specimen is not of a circular figure as the last, but one side projects in an angular form.

A t 40. A transverse section of a still larger Spine of an *Echinus*, *E. lucunter*; it exhibits a coarse areolar structure in its centre, as shown in Plate XIV. fig. 14; this is surrounded by a zone of finer reticulations, having at first a radiated arrangement, which afterwards becomes less and less so, and near the first row of pillars it entirely disappears; between this row and

the circumference of the spine, a distance of $\frac{1}{8}$th of an inch, there are three other rows, each pillar being separated from its neighbours by a small oval perforation. The diameter of this specimen is $\frac{5}{8}$ths of an inch, and its structure may be said to approach very near to that of the genus *Cidaris*. *Presented by Dr. W. B. Carpenter, F.R.S.*

A t 41. A transverse section of a Spine of an undescribed species of *Cidaris*, taken from near the base ; it consists of a central portion about $\frac{1}{16}$th of an inch in diameter, composed of a series of hexagonal cells of large size, from the outer margin of which a much finer network commences, and is continued to the circumference of the specimen ; this network may be best described as consisting of a series of radii, between which certain transverse bands are arranged at nearly equal distances, so as to form small, more or less circular cells or openings ; as the radii are closest together near the centre, there also the cells are the smallest, and they will be found to increase in size gradually, and to attain their greatest dimensions at the outer margin of the specimen. A faint indication of a row of pillars may be seen about $\frac{1}{16}$th of an inch from the circumference of the section. *Presented by the Rev. James Landy Brown.*

A t 42. A transverse section of the same Spine, taken from a spot still nearer the base ; it exhibits the coarse hexagonal network in the centre, and the finer radiated one around it ; as described in the preceding preparation, this arrangement prevails to within $\frac{1}{16}$th of an inch of the margin, where an indication of a circle of small pillars may be seen, these being formed by a dilatation of the radii at this part ; between them and the circumference of the section, the arrangement of the reticulations is in some parts coarser, and not very distinctly radiated.

Presented by the Rev. James Landy Brown.

A t 43. A transverse section of a Spine of a small undescribed species of *Cidaris*, consisting of a centre composed of a network of hexagonal cells of large size, around which a series of equidistant radii with transverse connecting bands are arranged ; these, as described in Preparation A t 41, form with the radii numerous cells, increasing in size gradually from the centre

towards the circumference. The margin of this specimen is slightly undulated, and is composed of a band or zone of calcareous matter, having fifteen large oval perforations at certain regular distances ; this band presents no reticulated structure, but the radii before mentioned are continued through it as far as the circumference: the transverse bands however are wanting. A segment of this spine is represented in Plate XIV. fig. 16, and the radii in the band appear to be composed of tubuli larger than those of dentine.

A t 44. A transverse section of another Spine of the same *Cidaris*, exhibiting similar appearances in the central portion to those described in the preceding preparation, but the marginal zone presents a rather different arrangement; on one side of the section, a portion of the same structure as that last described is however present, but on the opposite margin nothing but a series of more or less angular transparent tubercles like the pillars of the *Echini* are to be seen; these gradually become longer and less transparent, and ultimately form the same kind of structure as that composing the zone in the preceding preparation, and a small portion of which has just been stated to be here present.

A t 45. A transverse section of another Spine of the same *Cidaris*, presenting a similar structure to that of the two preceding preparations, but both the central portion and the marginal zone are of a rich brown colour; the latter has an indented edge, and exhibits very plainly the nature and disposition of the tubular radii.

A t 46. A vertical section of a Spine of the same *Cidaris*, exhibiting many points of great interest. When compared with that of the *Echinus*, forming Preparation A t 35, the first thing that strikes the observer is the absence of all appearance of cones, the coarser markings of the specimen being more or less parallel. When examined with a power of 100 diameters, the base, which is of a hemispherical figure, will be found to be composed of an exceedingly fine reticulated structure disposed in a radiated form, the direction of the radii being from the centre of the spine towards the base. This fine structure appears to end suddenly in the centre of

the spine, and from a curved line so formed numerous parallel columns of reticulated structure arise, each being connected to its neighbour by means of broad transverse bands, the columns in the centre being stronger and differently marked from those nearer the circumference. On the margin of the section the semi-transparent zone is seen; its free edge is slightly undulated, large tubuli being prolonged from the reticulated structure into it, some of which terminate in a very minute projection-like spine. This section is represented in Plate XIV. fig. 8.

A t 47. A transverse section of a Spine of a large undescribed species of *Cidaris*, exhibiting a structural arrangement somewhat like that of Preparations A t 43 and 45, but with this difference, viz. that all the radii form a series of beautiful arches on the outer side of the coarse central network; this also presents the peculiarity of having a number of small cells grouped together in circles, each being surrounded by larger cells. The margin of the section is of a brown colour and nearly uniform breadth, and presents traces of large circular perforations at certain regular distances.

Presented by Mr. J. T. Norman.

A t 48. A transverse section of the same Spine, in which the central network of large cells is wanting, whereby the curious series of arches formed by the radii are very beautifully shown. *Presented by Mr. J. T. Norman.*

A t 49. A transverse section of a Spine of a *Cidaris* of unknown species, exhibiting a large central spot composed of coarse hexagonal reticulations, around which are a series of beautiful arches, formed by the meeting together of the radii. The margin of the specimen is imperfect; it presents similar appearances to those described in many of the other sections of *Cidaris*, and also shows that the radiating tubuli are the most durable part of the margin, as in very many instances they may be seen projecting beyond it in the form of spines, the grey calcareous matter between them having been broken away. A segment of this spine is represented in Plate XIV. fig. 18. *Presented by the Rev. James Landy Brown.*

A t 50. A transverse section of a fossil Spine of a *Cidaris* from the Chalk, exhibiting the same peculiarities of reticulated arrangement as the recent speci-

mens. The centre consists of a mass of large cells, around which is a series of smaller ones, disposed in a radiated manner; the circumference of the section is indented, but there is no semi-opaque layer or margin, as in the specimens of *Cidaris* before described.

If the ten specimens last described be compared with any of the preceding twenty-seven, it will be readily seen that the sections belonging to the former differ in many respects from those of the latter, a mere ocular inspection in most cases serving to distinguish them. When viewed with the microscope, the minute structure fully bears out what could be predicted of their true nature with the naked eye. The sections of the spines of the *Cidaridæ* will be found in almost all cases to be deficient in the concentric rings or rows of pillars, rarely more than one being seen, and this not very strongly marked; in addition, the spines are in most instances coated with a thick coloured layer, which in transverse sections presents only a radiated structure, the radii from the central portion of the spine being continued into it. The spines of the *Echinidæ*, on the contrary, always exhibit a greater or less number of concentric rings or pillars; these are prolonged from one ring to the other in the form of radii, and the margin when perfect is always surrounded with the largest row. A comparison of fig. 11 in Plate XIV. with that of fig. 16, will give a better idea of the differences in structure in the spines of these two families than any written description*.

c. *Pedicellariæ.*

On the external surface of the shell of many *Echini*, in addition to the spines, certain claw-like appendages are found; these have received the name of *Pedicellariæ*, and have by some observers been considered as parasites; if however a single specimen be carefully detached from the shell, it will be found to exhibit certain peculiarities in structure that must convince the most sceptical that it is an organ belonging exclusively to the animal. The *Pedicellariæ* were first described by Müller in the 'Zoologia Danica,' and have since been investigated with great care by M. Sars, a Norwegian clergyman, and by Prof. Valentin, both of whom have detected in their calcareous skeleton the same peculiar arrangement of reticulated structure as in the spines of the same animals; they are not exclusively confined to the *Echini*, but with very few exceptions are found upon

* For further information on the structure of the spines of the Echinodermata, see Appendix F.

the bodies of all Star-fishes, and occur in the greatest abundance around the bases of the spines. Each specimen consists of a calcareous stem, supporting on its summit a dilated body like a pair of forceps, having either two or three teeth, all of which, as well as the stem, are enclosed in a soft animal substance. In structure the stem and teeth are reticulated, and the former has both of its extremities expanded into a knob. Müller and Valentin describe three varieties; one called "gemmiform," generally situated around the tubercles; another named "tri-dactyle," larger in size than the last, and occurring around the tubercles supporting the largest spines, whilst the third, or "snake-headed," is found principally upon the buccal membrane. The pedicellariæ of Star-fishes, on the contrary, have a membranous stem and a head resembling a pair of forceps with two blades; these are continually opening and shutting, and their office, as suggested by Prof. Owen, is probably that of keeping the shells of these animals perfectly free from parasitic and other intruders.

A t 51. Pedicellariæ of the gemmiform class, obtained from the outer surface of the shell of a small *Echinus*, *E. miliaris*; it consists of a three-lobed expanded extremity or head attached to a long central bony stem. The head consists of soft animal matter surrounding three pairs of hooked calcareous jaws; it is articulated to the stem by means of a neck, and at this point the stem commences by a spherical enlargement; it is of a circular figure, on an average $\frac{1}{200}$th of an inch in diameter, and in every respect its structure resembles a small spine of the same animal. A perfect specimen is represented in Plate XIV. fig. 19.

A t 52. The calcareous skeleton of four of the same Pedicellariæ, obtained by macerating the entire organ in Liquor Potassæ; the central stem is about $\frac{1}{6}$th of an inch in length, and terminates both above and below in a dilated extremity; the former, or that to which the head is attached, being more globular than the latter. The calcareous matter enclosed within the head, and which for the sake of distinction may be termed the jaws, consists of three portions; thin and flattened below, apparently for the attachment of muscles, and sharp and bent nearly at right angles above in the form of a tooth. These parts are represented at *a* and *b* in Plate XIV. fig. 19, and all exhibit the peculiar reticulated structure characteristic of the

shells and spines of the Echinodermata. On either side of the jaws may be seen a row of small bicurved spicula, somewhat resembling those of certain sponges, but differing from them in having more than one hooked process extending outwards from the point where the principal curves commence. These are shown at *c, c* in Plate XIV. fig. 19, and at *d* more highly magnified.

A t 53. Pedicellariæ removed from the external surface of an *Echinus*, *Echinus esculentus*, from the Society Islands; they differ from the preceding in having a longer stalk, a smaller head, and in having no spicula; each jaw also terminates in two tooth-like processes. All parts of the calcareous framework are more or less of a purple colour, and present the reticulated structure characteristic of the spines of the same animal.

A t 54. Pedicellariæ removed from the outer surface of a large Star-fish, *Asterias rubens*; the skeleton consists of little else than the part called the head, and is composed of two valves very much resembling a common mussel in shape, each valve having a semicircular notch, which, with its fellow on the opposite side, forms a large foramen; the edges of the valves are minutely serrated. In structure this organ resembles that of the shell of the same animal. One specimen is represented in Plate XIV. fig. 20 *a*, and portions of another, more highly magnified, at *b* and *c*.

Subseries VII. *Skeleton of Insects.*

The skeleton of Insects belongs to the *dermal* class, being not only external to the soft parts, but formed by a modification of the true skin or *corium*. It is composed of a peculiar animal principle termed *chitine*, of a horn-like appearance, but differing from horn, nails and all other cuticular developments in many points, principally however in being insoluble in boiling caustic potash.

The ultimate structure of the skeleton is cellular, and in many insects the cells are retained as a permanent character, but in others they have become so intimately blended or fused together, that all trace of them has disappeared. In some insects the skeleton is comparatively soft and membranous, in others as

tough as leather ; whilst in the elytra, and some parts of the cranium of many beetles, the chitine is said to be further consolidated by the deposition of a certain amount of the phosphates of lime and magnesia in its substance, whereby these portions of the skeleton are rendered almost as dense as bone. The corium is only occasionally provided with a distinct cuticular and a pigmental layer ; and the appendages to the skin, such as hairs and spines, are not developed from the cuticle and rete mucosum only, but from all three. The varied and gorgeous hues displayed in this vast tribe of animals are not entirely due to the pigment, but in the butterflies and certain others presenting an iridescent appearance, the colours are produced by the decomposition of light, owing to its falling at particular angles upon the grooved surfaces of their cuticular covering.

When the skeleton is very thick, it may be shown that it is made up of a series of laminæ, between which are certain canals or channels, as in bone, for the conveyance of the nutritious juices ; but more commonly large tracheæ occupy the same situations.

The skeleton of Insects, like that of Sponges and Echinoderms, is often met with in a fossil state, and in many specimens the true cellular structure may still be discerned.

A u 1. A small red Ant, *Myrmica domestica*, the greater portion of the horny skeleton of which is composed of a series of hexagonal cells of nearly uniform size, resembling to a certain extent the cornea of some insects, or a layer of tesselated epithelium ; their walls are very delicate, and no trace of a nucleus can be discerned in the interior of any of them. The average diameter of the cells is $\frac{1}{2000}$th of an inch.

A u 2. A portion of the Elytron of a Diamond Beetle, *Entimus imperialis*, consisting of a thick layer of horny matter, exhibiting a very minutely granular structure, the diameter of the granules not exceeding $\frac{1}{16000}$th of an inch ; they are arranged mostly in parallel and diagonal lines, and in many parts present appearances similar to the markings upon the loricæ of certain infusoria.

A u 3. The entire skeleton of a Myriapodous Insect, *Geophilus longicornis*, the

greater portion of which, and more especially the parts about the cranium, exhibit a cellular structure; the cells are of hexagonal figure, and measure on an average $\frac{1}{2000}$th of an inch in diameter; like those of the Ant they have thin walls, and present no trace of nuclei.

A u 4. A portion of the skeleton of a larva of a large Water Beetle, *Hidröus piceus*, exhibiting little or nothing else than a cellular structure. The cells are of large size, on an average $\frac{1}{800}$th of an inch in diameter, and are provided with very thick walls, all, with very few exceptions, as represented in Plate XIII. fig. 18, showing a tuberculated structure in their interior; whilst those having no tubercles exhibit a large central nucleus instead: this however is probably present in the other cells, but is obscured by the tubercles. *Presented by Mr. J. T. Norman.*

A u 5. One of the antennæ of a male Cockchafer, *Melolontha vulgaris*, consisting of a jointed pedicle supporting seven thin oval leaflets; these last exhibit a beautiful cellular structure somewhat like that of the preceding specimen, but the cells, instead of being of a hexagonal figure and close together, are in this specimen more or less oval, and situated at a little distance from each other. The cell-wall is thin, and sometimes slightly jagged; each cell exhibits a large oval nucleus, having in all cases a small nucleolus within it: both these appear to project above the general level of the cell in the form of a cone. A portion of this preparation is represented in Plate XIII. fig. 17.

A u 6. Another antenna of a male Cockchafer, having one of its leaflets considerably injured; this however is very valuable, as showing that the leaflets are made up of two layers of cellular structure, the cells in each being perfectly similar, but not placed exactly one over the other. The average long diameter of one of the cells is $\frac{1}{800}$th of an inch, whilst that of the nucleus is $\frac{1}{1200}$th, and that of the nucleolus $\frac{1}{8000}$th.

Presented by Mr. J. W. Bond.

A u 7. A portion of the horny skeleton of *Dyticus marginalis*, in which the cells are so intimately blended together, as to exhibit no trace of cellular structure.

A u 8. A horizontal section of a portion of the dense horny matter composing the head of a large Beetle, *Dynastes Hercules*. The greater part of this specimen exhibits no trace of cellular structure, but there are, however, certain spots in which cells may be distinctly seen; they are of small size, on an average rather less than $\frac{1}{2000}$th of an inch in diameter, and like those in the larva of the *Hidrous*, described in Preparation A u 4, contain a certain amount of granular matter, which renders them the more easy of detection. On one edge of the same section may be seen numerous parallel bands forming a connected layer; in some parts their edges are slightly serrated, and their surfaces minutely granular. They proceed in straight lines, and in one spot there is an appearance as if the cells before alluded to were nothing more than these bands divided transversely.

A u 9. Vertical sections of a portion of the horny skeleton of a Buprestis, *B. castanea*, consisting of a series of laminæ arranged one over the other; they vary much in thickness, and generally speaking, a broad one is situated between two that are much narrower; all however exhibit certain transverse markings, and in many parts in which the laminæ are not very distinctly seen, the markings serve to point them out. Large tubercles are developed from the inner surface of the sections for the attachment of muscles; these exhibit in a very remarkable manner the arrangement of the laminæ: they are nearly all of the same breadth, and follow the curved outlines of the tubercles.

A u 10. Vertical sections of a portion of the thorax of *Dynastes Hercules*, some of which exhibit the same laminated arrangement of the horny matter as the preceding preparation; in these the transverse markings above alluded to are also present, but two of the sections are composed of fine laminæ, arranged in a series of curves; these in certain parts cross each other at various degrees of obliquity, and produce a cellular structure, the cells being of a rhomboidal figure; this is particularly well shown in one of the sections, as the edges of the laminæ are of a dark colour.

A u 11. Vertical sections of one of the elytra of *Buprestis castanea*, exhibiting a series of minute laminæ arranged in two layers, a superficial and a deep,

which are separated from each other by vertical bands or pillars composed of laminated tissue; between the bands canals are left for the passage of tracheæ, some fragments of which are still visible. In the centre of the sections the pillars are a great distance apart; at the edges, on the contrary, they are very close together, and so much thickened above and below as to give the canals a circular appearance. In all cases the inner wall of the canals is of as dark a colour as the outer or pigmental layer of the section.

Subseries VIII. *Skeleton of Crustacea.*

The skeleton of the Crustacea, like that of Insects, being external to the soft parts, belongs to the *dermal* class; in the greater number of species it is thin and membranous, or horny, as in Insects; in others it is composed of a horny material, thickened with calcareous matter; in these there is not unfrequently a distinct series of pigment cells of a stellate figure, as in the skin of certain Fishes and Reptiles. In the more highly organized members of this family, the Decapod Crustacea, as for example the Crabs and Lobsters, the skeleton has been described* as being composed of three layers, viz. the epidermis or cuticle, the rete mucosum or pigment, and the corium. The epidermis is of a horny nature, being generally of a more or less brown colour, and under the highest magnifying powers presenting no trace of structure; it invests all the outer parts of the shell, and has in many instances large cylindrical or feather-like hairs developed from certain portions of its surface. The rete mucosum consists either of a series of hexagonal cells forming a distinct stratum, or of pigmental matter diffused throughout a certain thickness of the calcareous layer; in the Crab and Lobster it is very thin, but in the Cray-fish it occupies in some parts more than one-third of the entire thickness of the shell; when examined microscopically, this portion appears to be composed of a large number of very thin laminæ, which are indicated by fine lines taking the same direction as the surface of the shell, the number of lines being the greatest in the oldest specimens; these layers, even in the Cray-fish, are covered by a thin stratum of very minute hexagonal cells, without any trace of nuclei in their interior.

The corium is the thickest layer of the three, being the one on which the

* Carpenter in Reports of British Association for 1844 and 1847.

strength of the shell depends in consequence of the calcareous material deposited in it: when a vertical section is examined microscopically, it is found, in the Crab at least, to be traversed by parallel tubuli, like those of dentine, as shown in Plate XIII. fig. 29, giving off lateral branches at certain, nearly regular distances, as represented in fig. 28. The tubuli extend from the inner to the outer surface of the shell, and are occasionally crossed nearly at right angles by wavy lines, probably those of growth, as shown in fig. 25; these, however, differ from the coarser lines formed apparently by the branches of the tubuli, as shown in fig. 29. If a horizontal section of the same shell be made so that the tubuli be divided at right angles to their length, the surface will clearly exhibit their open mouths surrounded by calcareous matter. This structure is common in all parts of the shell of the Crab; but, according to Dr. Carpenter, who has investigated the subject with great care, the best examples will be found in the black portion of the large claws. An arrangement somewhat similar is also to be met with in the Lobster and Cray-fish, but in these animals both the striæ corresponding with the tubuli, and those with the lines of growth, are on so minute a scale, that it is only in the outer or pigmental layer that the tubuli can be well seen; the other portions of the shell present both sets of striæ of uniform size. In the Shrimps and very small Crabs, the deposition of the calcareous matter takes place in concentric rings like those of agate, and occasionally small centres of ossification, as shown in fig. 21, with radiating striæ are to be met with in the former animals. Very few Crustacea have a skeleton quite free from tubercles or other projections from their outer surface; even the smallest Crabs have more or less of them. In some cases the tubercles are composed of concentric rings of calcareous matter; in others, as the common Crab, numerous papillary elevations of the inner or deep surface of the shell take place, the bases being always more or less deeply coloured, and the apices white; by this arrangement all the brown or otherwise coloured surfaces present a dotted appearance. If the calcareous portion of the shell be treated with acid, a distinct animal structure or basis is left behind, and the characters of the part, whether tubular or otherwise, will in most cases be very accurately preserved. The calcareous matter, like that of bone, generally presents a more or less granular appearance, and not unfrequently the granules are of so large a size, and so angular in figure, as to resemble certain forms of rhombohedral crystals.

The above description comprises the principal opinions entertained of the structure of the skeleton of Crustacea, by Dr. Carpenter, M. Levalle, and other high authorities; but however true some of the points may be as regards the larger members of the *Decapoda*, they are not entirely borne out by the examination of many of the smaller members of the same order. Thus, for instance, it has been ascertained, in the preparation of the following series of specimens, that the horny epidermis is not always structureless, but is most frequently composed of hexagonal cells, on an average $\frac{1}{2000}$th of an inch in diameter; and also that there is no distinct cellular layer containing the pigment, but that the blue or red colours which many Crustaceans present are not due to pigmental granules contained in cells, but to some peculiarities either in the composition or arrangement of the molecules of the calcareous matter; neither are the tubuli, like those of dentine, to be seen, unless in very thick portions of the shell, and in the large claws. In some small crabs the shell appears to be composed of little else than the hexagonal cells of the cuticle, as shown in Plate XIII. fig. 22; in others, as shown in Plate XV. fig. 12, similar cells may be seen overlying another layer, in which the calcareous matter is deposited in the form of very minute granules; from this last-described variety of shell to that of the largest crabs, every gradation in thickness may be met with, and in all, the hexagonal cells of the cuticle are still present; this is particularly striking in the large Crayfish, as the cuticle of this Crustacean may easily be separated from the calcareous matter by means of a knife, and even after boiling will exhibit the true cellular character; but whether the specimen be taken from the white or red parts of the shell, no pigmental layer is connected with it.

a. *Skeleton composed of horny matter.*

A v 1. A small Glass Crab, *Phyllosoma*, the skeleton of which consists of transparent horny material; it is divided into two portions, the anterior or cephalic, and a posterior or thoracic: the former presents little or no structure; but the latter, or that which bears the legs, is covered with very minute rounded tubercles.

A v 2. Two valves of an Entomostracous Crustacean, *Daphnia pulex*; both of which exhibit a horny skeleton composed of a series of very delicate hexagonal cells, like those of the Insects described in Preparations A u 3, 4, 5.

A v 3. The carapace of a small transparent Crab, exhibiting a beautiful series of hexagonal cells; some parts of the upper surface of the specimen have small conical tubercles projecting from them, whilst others are covered with short feather-like hairs; in the intervals between these and the tubercles, the hexagonal network may be plainly seen: none of the cells exhibit any trace of nuclei.

A v 4. A portion of the carapace of a small British Crab, of the genus *Portuna*, which, like the preceding, exhibits a beautiful series of hexagonal cells without nuclei; but in this specimen there are no hairs, and only a few tubercles; the cells may therefore be plainly seen, even with the lowest magnifying powers. A small part of this preparation is represented in Plate XIII. fig. 22, and, as there shown, the cells have walls of considerable thickness.

b. *Skeleton composed of horn with a slight admixture of calcareous matter.*

A v 5. A portion of the carapace of a small brown Crab of the swimming or Pinnipede family, exhibiting on all parts of its surface (with the exception of the apices of the large tubercles) a coating of hexagonal cells without nuclei; if the edges of the specimen, as well as those portions in which the hexagonal structure is at first sight not plainly seen, be carefully examined, it will be found that beneath the cells there is a copious deposit of very minute calcareous granules; in other portions, in which the cells are most plainly shown, the deposit of the same granular matter may be noticed even in the cells themselves. Upon the tubercles there are no cells; these portions of the carapace, which are of a white colour, appear to be composed of two kinds of structure, viz. superiorly of calcareous granules of larger size than those beneath the cells, and inferiorly of fine radiating lines or striæ like those from the common Crab, shown in Plate XIII. fig. 27, these parts being evidently derived from a protrusion outwards of the deepest layers of the calcareous material.

A v 6. A portion of the carapace of a smaller swimming Crab, in parts of which a red colour is distinctly visible; when this preparation is examined with a power of 200 linear, the layer of hexagonal cells, which may be regarded

as cuticular, can be distinctly traced over the whole of the upper surface; some of them appear to have minute granules of calcareous matter deposited in their interior, whilst others overlie a thick stratum of the same granular matter. The red colour is not contained in any cells like those of the skin or eye of the Vertebrata, but is diffused over certain parts of the specimen situated beneath the cells; it presents no structure, but gives a shade of colour to the granules that lie above it. A portion of this preparation is represented in Plate XV. fig. 12; at *a* are shown the hexagonal cells, and at *b* the granules beneath the cells, and at *c* the same deposited in the cells.

A v 7. A portion of the same carapace mounted in Canada balsam, in which the hexagonal layer or cuticle, as well as the granules and colouring matter, are very plainly shown.

A v 8. A portion of one of the swimming feet of the Crab, the carapace of which forms Preparation A v 3; it exhibits in some parts of its surface the cuticular layer of cells, and in others a series of short stout feathery hairs; but between the two layers of horny matter forming the foot, may be seen the commencement of the deposition of the calcareous material; this is not exactly in the form of distinct isolated granules, but in concentric rings of granular matter, somewhat like many specimens of agate. A portion of this preparation is represented in Plate XV. fig. 6.

A v 9. The carapace of a very small Crab, probably of the genus *Matuta*, having a spine about $\frac{1}{16}$th of an inch in length projecting from each side. Under a power of 100 linear, this carapace, which is quite transparent, exhibits a layer of hexagonal cells, like those described in Preparation A v 3, and beneath them may be seen the commencement of the deposit of calcareous matter: this, as in the preceding specimen, consists of minute granules arranged in a series of concentric rings, like those of agate; in the greater number of instances, the hexagonal cells of the cuticle may be distinctly seen to pass over the calcareous deposits.

c. *Skeleton composed principally of calcareous matter.*

A v 10. A horizontal section of one of the thin plates of the tail of a Lobster, *Astacus marinus*; from not having been boiled, it presents a blue appear-

ance over the whole of its surface, except on one edge, where the colour is red; when examined with a power of 500 linear, a distinct hexagonal network, like that before described in the small crabs, can be plainly seen in all parts that have not been interfered with in the preparation of the specimen; but in the others, a very much smaller hexagonal network is also visible; this, however, when carefully examined, is found to be due to the presence of innumerable granules of calcareous matter, which are in some places so angular as to present the appearance of crystals. The granules are occasionally arranged in rows in the same direction as the walls of the cells. In all parts of the specimen that have been ground, nothing but the granules are seen; but in those which have not been so treated, both hexagonal cells and granules are found. A portion of this preparation is represented in Plate XIII. fig. 30; at *a* are shown the hexagonal cells, and at *b* the angular granules.

A v 11. A similar preparation of one of the tail plates of the Lobster, exhibiting the blue colour and the hexagonal and granular structure like that of the preceding specimen. The edge nearest the name is red, and presents only a few patches of granules; but as we proceed towards the centre they become more apparent, and the centre itself is rendered opaque by their abundance; the hexagons are visible only in the parts untouched in the grinding. On the opposite edge to that exhibiting the red colour, may be seen a curious arrangement of large pigment cells, of much greater size than those in the layer that has been termed cuticular.

A v 12. A similar section of the tail plate of a Lobster, which by being heated rather too much in the Canada balsam, has lost its blue colour and become more or less red. It exhibits in certain parts both the hexagons and the calcareous granules, and in addition certain large irregular spots of a black colour, which appear to be made up principally of very minute prismatic granules in the form of crystals.

A v 13. A similar section of the tail plate of a Lobster, which was heated until it became red, and was then mounted in the Canada balsam; it exhibits one large opaque spot composed of the prismatic crystals, and one corner of the specimen has been ground so thin as to show only one layer of the

ordinary calcareous granules: these therefore are in a favourable situation for being examined with the highest powers.

A v 14. Three vertical sections of the shell of a Lobster after having been boiled; each exhibits a broad margin of a bright red colour, and a rather broader white portion beneath it; both appear to be nearly of the same structure, and under a low power present vertical and horizontal striæ; when however the two layers are examined with a power of 250 linear, the vertical striæ will be found to be the larger, and to be made up of slightly undulating tubuli; these are plainly shown where not permeated by the balsam. The red colour can be distinctly seen not to be contained in cells, but to consist of a finer and more compact tissue than the other part, and to have the colouring matter equably diffused through it.

A v 15. A portion of the shell of another Lobster, which has been treated with acid to remove the earthy material; the peculiar fibrous structure still remains in certain parts, but a cuticular layer composed of hexagonal cells may now be seen; it has been detached from the deeper layers, and is best displayed on the edges of the specimen. When the calcareous matter was being removed, groups of prismatic crystals were at one time visible; these however were soon dissolved with effervescence in the same way as the granules by which they were obscured.

A v 16. A portion of the cuticular layer removed from the outer surface of a claw of a large Cray-fish, *Palinurus vulgaris*: as shown in Plate XV. fig. 10, it is composed of a series of hexagonal cells without any trace of nuclei.

A v 17. Two vertical sections of the shell of the Cray-fish, one having the lime removed; both exhibit an arrangement of parts similar to that of the Lobster described in Preparation A v 13. The upper margin of each is red for about the space of $\frac{1}{40}$th of an inch; the remainder is either of a transparent or of an opaque white colour: the structure of both is nearly the same, viz. exhibiting vertical and horizontal striæ, the former in certain spots having a columnar or tubular appearance. One of these sections is represented in Plate XV. fig. 5, the other having the lime removed in fig. 11.

A v 18. A portion of the carapace of a small British Crustacean, of the genus *Galathæa*, which has been placed in dilute acid for a short time in order to remove only a small part of the calcareous matter; the action of the acid may be best seen on the edges, the lime having been entirely removed from them, and a very beautiful hexagonal cuticle brought into view. The portions of the carapace not acted on by the acid are situated in the centre; in these may be seen a very copious deposit of calcareous matter in the form of small nodules. The carapace is ribbed, and on each rib very beautiful feathery hairs are situated.

A v 19. A portion of the shell of the thorax of a large edible Shrimp, *Crangon vulgaris*, thickly coated in some parts with calcareous matter exhibiting two distinct kinds of arrangement, one in the form of concentric rings, and the other like radiating crystals or spicula; the latter kind is the most common, and is not unfrequently found in the centre of the rings, as shown in Plate XIII. fig. 21, which is a representation of a portion of this preparation.

A v 20. A portion of the shell of the thorax of another Shrimp, after having been partially treated with acid; it exhibits not only the traces of concentric rings, but in many other parts of the surface a series of curious-shaped nodules are present, some in the form of circles or stars, and others in the form of daggers; in most of these the minute granules of earthy matter are still to be seen.

A v 21. A portion of the new shell of a river Cray-fish, *Astacus fluviatilis*, exhibiting very peculiar forms of structure; the entire upper surface is covered with short wavy lines or bands, in certain lights appearing to be folds in the membrane; these, however, on careful examination, are found to be elevations from the surface, which fit into corresponding depressions in the under surface of the old shell, soon about to be shed. Upon many parts of the surface of this specimen may be seen groups of small prismatic crystals, like those described in Preparation A v 15, but in all the others minute granules of calcareous matter are deposited beneath the layer of hexagonal cells of the cuticle. In this specimen are included

some pieces of the old shell, having their inner surface uppermost; these exhibit numerous wavy depressions, into which, as before described, the elevations in the new shell were probably fitted. At the end of one of the fragments of the old shell, two sets of fine lines may be seen crossing each other at nearly right angles, whereby, as shown in Plate XV. fig. 19, a series of angular markings are produced very much resembling the granules described in the Lobster; this may be considered as the matrix in which the calcareous matter is deposited. Two portions of the new shell are represented in Plate XV. figs. 15 and 16. If the outer surface of the specimens of old shell be examined, the calcareous matter will be found in an unconnected layer, and to be composed of rounded nodules; these are absent in certain spots, so that a deeper layer, having wavy markings like those on the new shell, may be discerned below them.

A v 22. A horizontal section of the shell of a Crab, *Cancer pagurus*, ground on both surfaces; it exhibits to the naked eye numerous large circular white spots, surrounded by a groundwork of a pink colour; when the section is examined with a power of 100 linear, the white spots will be found to be composed of a semi-opaque granular substance, having elongated cells and an appearance of radii on their outer margin, as shown at *a* in Plate XIII. fig. 27; around these is a network of equal-sized hexagonal cells, as shown at *b*, or more highly magnified in fig. 26, in some of which are granules arranged in a stellate form, as represented in Plate XV. fig. 8*, and when the granules are very black the cell-walls appear transparent; but the tint of the cells, and in many cases of the granules as well, is due to the presence of a colouring principle equably diffused throughout the deeper-seated layers of calcareous matter.

Presented by Dr. W. B. Carpenter, F.R.S.

A v 23. A horizontal section of the shell of another Crab that has been ground on the under surface only; it exhibits an arrangement of hexagonal cells, and of tubercles similar to that of the preceding specimen, but the latter are very opaque. The cells may be traced over the entire surface of the

* Appendix G.

specimen, except the tubercles, and beneath them is a light brown tint, which gives colour to the whole: some of the hexagonal cells are full of black granules ; others, as shown in Plate XV. fig. 7, are structureless.

A v 24. Three horizontal sections of a portion of the outer black surface of one of the large claws of a Crab, all having been ground on the under surface only ; each presents a dark brown colour equably diffused throughout the whole of the specimen, but the tint is further deepened by a ring of hexagonal cells around the base of the tubercles. The cells can be readily seen in all portions of the surface, where the cell-wall is black, and with careful examination may even be traced in all parts except over the tubercles. This preparation clearly shows that there is no pigmental layer, and that the colouring matter is deep-seated, lying even below the bases of the tubercles, which in this specimen are also tinged with brown.

A v 25. A transverse section of one of the black claws of a large Crab, exhibiting under a power of at least 100 diameters, both circular and radiating striæ ; when these are carefully examined, it will be found that the former are lines of growth, and that the latter are tubuli, like those of dentine, passing from the inner to the outer surface of the claw. A portion of this specimen is represented in Plate XIII. fig. 25, under a power of 70 diameters, and in fig. 29, under a power of 250.

A v 26. A transverse section of one of the large claws of a Crab, made rather thinner than the preceding specimen ; it exhibits both the circular lines and the tubuli very plainly ; when examined with a power of 500 linear, the tubuli, as shown in Plate XIII. fig. 28, will be found to give off lateral branches at certain distances ; the aggregation of these in some cases form markings very like those indicating the successive stages of growth. In all parts of the specimen where the tubuli are not plainly seen, it may be shown that they do exist, but in consequence of having been filled with the Canada balsam are rendered very transparent. It may however be noticed that the margin of the section is very dense, and of a black colour, and that the tubuli cannot in all cases be traced through it.

A v 27. A vertical section of the same claw, in which the tubuli are cut at right angles to their length; when examined with a power of 500 linear, the open mouths may readily be seen, their average diameter being $\frac{1}{25000}$th of an inch; in this particular the skeleton of the Crab very strikingly resembles a section of dentine made at right angles to the direction of its tubuli. A portion of this preparation is represented in Plate XV. fig. 17.

A v 28. A transverse section of one of the large claws of a Lobster, exhibiting the wavy tubuli and the concentric lines of growth rather more plainly than the specimens from the Crab. The margin of the section is of a reddish hue, and when carefully examined will be found to be very dense, and to exhibit both smaller tubuli and concentric lines of growth than the white portion; in this point the section of the claw agrees with that of the carapace.

A v 29. Two transverse sections of one of the large claws of a Cray-fish, *Palinurus vulgaris*, exhibiting a tubular structure and concentric lines of growth, like those in the corresponding parts of the Crab and Lobster, but with a slight difference, viz. that both sets of markings are much smaller and closer together in this than in the latter animals. In some parts of both specimens, three distinct bands may be seen, each containing a different variety of structure, the most external being the narrowest, and exhibiting the smallest tubuli; the free edge is covered with the hexagonal cells of the cuticle, and the deeper-seated is generally of a red colour; the next layer is about twice as broad as the first, and is occasionally tinged of a red colour at the upper part; its tubuli and concentric layers are rather coarser than those in the outer layer; beneath this last is the broadest layer, in which the tubuli and concentric lines of growth are very plainly shown: they are however much smaller than those in either the Crab or Lobster.

d. *Tubuli in the horny skeleton.*

A v 30. A transverse section of the tip of the same claw of the Cray-fish, which is principally composed of brown horny material; this, like the calcareous portion, exhibits concentric lines of growth, and in addition several tubuli of very large size; these not only run through the layers of horn,

but are sometimes found lying loose on the inner edge which forms part of the cavity of the claw.

A v 31. A transverse section of one of the horny claws of a King Crab, *Limulus Polyphemus*, consisting of a series of concentric laminæ, having large tubes running from one margin to the other ; in some parts of the specimen the tubes occur at certain regular distances, but at the inner edge, which is of triangular figure, they are found in great numbers, and the extremities of some of them lie loose in the central cavity of the claw. The diameter of the tubes is $\frac{1}{4000}$th of an inch ; an entire section of the claw is represented in Plate XV. fig. 13, and the part containing the largest tubes in fig. 14.

Subseries IX. *Skeleton of Annelida.*

These red-blooded articulated animals are divided into three orders, viz. *Tubicolæ*, *Dorsibranchiata* and *Abranchia* ; of these the first are remarkable for inhabiting tubes either of horny or calcareous material, some of which are constructed of grains of sand, fragments of shell, &c., firmly agglutinated together by an animal membrane ; but others are formed of conical tubes of calcareous matter open at both ends, and not only resembling the shells of the Mollusca in external appearance, but like them possessing a more or less distinct trace of organic structure ; on this account this last form must be considered as the *dermal* skeleton, and as such belongs to the present class of preparations.

When examined microscopically, the shells of many *Tubicolæ* present but little evidence of cellular structure ; and when fractured, exhibit to the naked eye a crystalline appearance ; others, on the contrary, consist of numerous small calcareous prisms arranged in laminæ, and sections made in the transverse direction show that the shell is made up of a series of concentric zones, each being formed of minute radiating prismatic cells, amongst which tubuli are visible. The shells of this order of animals are remarkable for their curved figure, some species being bent like a tooth, whilst others are twisted in all directions.

A w 1. A vertical section of the shell of an Annelide, *Dentalium entale** ; it is composed of a series of laminæ, which exhibit a certain trace of pris-

* This shell is now classified with the Mollusca.

matic cellular structure, the prisms being of small size and arranged in planes at right angles to the length of the shell; the mode of distribution of the prisms is better seen in fractured portions than in those which have been ground. A portion of this preparation is represented in Plate XVII. fig. 3.

A w 2. A horizontal section of the shell of the same *Dentalium*, which is composed of many concentric zones of nearly equal breadth. Of these the outer one differs in structure from the rest; it exhibits a series of very minute concentric lines, and traces of short prisms arranged in the form of radii; the remaining zones, on the contrary, do not present either the concentric lines or the radiating prisms, but the parts corresponding to the prisms form laminæ which lie in planes situated more or less obliquely to each other, so that the resulting structure very much resembles that of certain shells of the genus *Cypræa*: a small portion of this preparation is shown in Plate XVII. fig. 4.

A w 3. A portion of a spiral tube belonging to a species of *Serpula* found on the outside of the shell of an oyster; it consists of a series of laminæ of calcareous matter exhibiting no trace of prismatic cellular structure, but principally composed of minute granules.

A w 4. A transverse section of the shell of a large species of *Serpula*, consisting of a series of concentric laminæ, some of which are composed of small prisms arranged in a radiated form; the inner layer is broader and more transparent than the others, and exhibits traces of prisms arranged diagonally, like those of *Cypræa mauritiana*; in all the layers there is a distinct tubular structure.

A w 5. A vertical section of the shell of the same *Serpula*, exhibiting a prismatic cellular structure, like that of the *Dentalium* represented in Plate XVII. fig. 3, but in addition numerous branching tubuli may be seen running amongst the prisms.

A w 6. A portion of the tube or case of an *Annelide*, composed entirely of small, nearly equal-sized particles of silica, cemented together by animal matter. A fragment of this preparation is represented in Plate XVII. fig. 23.

Subseries X. *Skeleton of Cirrhopoda.*

The skeleton of these animals, whether of the sessile or pedunculate tribes, belongs to the *dermal* class, and in almost every instance consists of calcareous matter arranged in the form of valves, as in the shells of *Mollusca*. To the naked eye, each valve is seen to be marked with strong curved lines, indicating the successive stages of growth.

When examined microscopically, the skeleton presents little or no trace of cellular structure, but appears to be composed of a dense mass of brittle calcareous matter arranged rather in a crystalline or a granular form; but near the base of the valves of certain of the sessile tribe, as for instance the *Balani*, there are two layers of shell separated from each other by a cancellated tissue resembling a diploë, as first described by Mr. Gray; this structure is represented in Plate XVII. fig. 12, and through the more transparent parts, as there shown, a branching tube passes.

A x 1. A horizontal section of one of the large valves of a Barnacle, *Pollicipes villosus*, taken from the inner surface; it exhibits to the naked eye a series of curved lines, indicating the different stages of growth; but when examined with a power of at least 100 linear, the calcareous material presents no trace of prismatic or other cells, but is everywhere more or less granular, the edges especially being very opaque; if these parts however be carefully examined, certain curved rows of very minute tubes, each surrounded by a broad transparent margin, will be found at intervals of $\frac{1}{25}$th of an inch, the direction of the curves being opposite to that of the lines of growth. A portion of the shell containing three rows of tubes is represented in Plate XVII. fig. 11.

A x 2. A horizontal section of one of the small valves of the same *Barnacle*, also taken from the inner surface; like the preceding specimen, it exhibits the dark curved lines indicating the successive stages of growth, together with the rows of tubes; these last are very numerous, and do not occur in single file as in the preceding preparation.

A x 3. A horizontal section of one of the small valves of the same *Barnacle*,

taken from the outside; it exhibits a series of curved lines running from one margin to the other, between some of which may be observed a row of tubes similar to those above described. The arrangement of the calcareous granules appears to be in lines at right angles to the curves, and on each edge may be seen some brown horny matter composed of narrow prismatic cells; in the neighbouring portion of shell there are appearances presented as though the calcareous matter had been deposited in an animal matrix of a similar kind.

A x 4. A transverse section of one of the large valves of the same *Barnacle*, exhibiting a laminated structure, the edges of which are composed of very opaque granular matter; running at right angles to the laminæ may occasionally be seen the tubes described in the three horizontal sections; they are on an average $\frac{1}{5000}$th of an inch in diameter, and pass through the laminæ surrounded by a margin of calcareous material more transparent than the other parts, whereby their tubular character is very plainly brought out; some of them present a pink appearance, but none can be traced from one edge of the valve to the other.

A x 5. A horizontal section of one of the valves of a Barnacle, *Balanus tintinnabulum*, exhibiting a central oval portion, around which several broad laminæ are developed; on the outer margins of these the structure is more or less cancellated: when examined under a power of 100 diameters, the laminated portion presents a granular appearance, but the margins, which are also granular, are composed of involutions or folds, and in the centre of each a tube may occasionally be seen. At the end nearest the number there is a row of small canals, which have been divided rather obliquely, and on the oblique side of each many minute tubuli may be observed.

A x 6. A portion of the base of the same *Barnacle*, reduced sufficiently thin to be transparent; it exhibits a cancellated structure at one end, the cancelli being of a circular figure; proceeding towards the opposite end, the section is composed of a series of nearly parallel opaque bands, connected by short transverse ribs; between the bands there is very frequently a

thin granular layer of shell. At the end nearest the name, the texture is more solid, and is remarkable for exhibiting two series of tubes, one large and branching, the other very minute and always more or less curved; some of the former are filled with black matter, and communicate in their course with two large oval sinuses.

A x 7. A transverse section of the base of one of the large valves of the same *Barnacle*, exhibiting on one margin a laminated arrangement of the shell tissue, but on the other a series of small involutions of the laminæ, through the centre of which a branching tube passes; in some parts the tubes appear empty, but in others full of opaque granular matter; they all have an opening on the outer surface of the valve. A portion of this specimen is represented in Plate XVII. fig. 12, in which may be seen four of the tubes passing through the cancellated structure.

Subseries XI. *Skeleton of Mollusca.*

The animals belonging to the molluscous sub-kingdom are divided into six classes, *viz. Tunicata*, *Brachiopoda*, *Lamellibranchiata*, *Gasteropoda*, *Pteropoda*, and *Cephalopoda*; of these, all, except the *Tunicata* and a few of the *Pteropoda*, are provided with a hard calcareous *dermal* skeleton, known as *shell*; in some of the Gasteropoda and Cephalopoda, however, the shell is of very small size in proportion to that of the animals; but in the former class, if it be absent in certain species when in the adult condition, it was present when the same individuals were in the embryonic state.

Shell has usually been regarded by conchologists as extra-vascular and inorganic in its nature, and as being composed of calcareous matter, exuded from the surface of the mantle of the animal; more recent investigations, especially those of Dr. Carpenter* and Mr. Bowerbank†, have proved that it always possesses a more or less distinct organic structure, and like the epidermis and other tegumentary tissues of the higher animals, was originally developed from cells which in process of growth have become hardened by the deposition of calcareous matter in their interior.

* Reports of the British Association for 1844 and 1847.

† Transactions of Microscopical Society, vol. i.

According to Dr. Carpenter, whose researches on this subject are not only the most extensive but the most valuable, the shells of the Mollusca may be divided into two primary classes, deriving their names from the condition in which the animal basis exists in the shell; this is either in the form of cells or of membranes; hence they are called the *cellular* and the *membranous*. The former is the most common condition, but the latter frequently presents a few important varieties of structure that must here be mentioned; one of these is termed *nacreous*, and is caused by the membranous basis of the shell being gathered up in plaits or folds one over the other, whereby a pearly appearance is produced. The membranous shell tissues may also be traversed by minute tubes, as shown in Plate XVI. fig. 19, commencing in the inner surface of the shell, and passing through the several layers as far as the epidermis; this structure is usually found only in ordinary membranous shell tissues.

Another variety of structure now remaining to be described is that termed *cancellated*, that is, where two layers of shell are separated by a series of large cells or chambers, like the diploë of the skull or the cancelli in bone; this structure, as before stated, is common in the base of the sessile *Balani*, and according to Mr. Gray, is to be found in a species of Oyster, named by him *Ostrea purpurea*.

The *earthy* matter of shell consists principally of carbonate of lime, but there are many species in which a slight proportion of the sulphate or phosphate is also present; it is deposited in the interior of cells, and is generally considered to be in a state of crystalline aggregation, and in certain shells, especially in that of the common Oyster, as shown in Plate XVI. fig. 14, perfect rhombohedral masses resembling crystals are found; in these cases the animal cell not having sufficiently controlled the mode of deposition of the earthy particles, they have in consequence assumed the crystalline form. There are however some few instances, as in the tooth of *Mya arenaria*, represented in Plate XVII. fig. 15, in which, even in the interior of the cells, the carbonate of lime appears to have crystallized in a radiated figure. When rendered sufficiently thin, all portions of shell void of colouring or chalky matter are transparent, and possess the peculiar property of depolarizing light in the same way as carbonate of lime in its crystalline state, where no animal matter is present.

The *animal* basis of shell, as before stated, may exist either in the form of a

plain or plicated membrane, but most frequently consists of an assemblage of cells of hexagonal figure, elongated into prisms, each of which has a distinct cell-wall exhibiting a series of transverse lines, showing that the prism is formed by the coalescence of flattened cells, originally placed one upon the other, as represented in Plate XVII. fig. 20.

In many shells, in addition to the animal matter existing in the form of cells or of membranes, there is found an epidermis of a more or less horny nature termed the *periostracum*; this sometimes exhibits a cellular structure, but more frequently is either structureless or composed of fibres which follow the sinuosities of the shell; in all the *Mytilaceæ* the periostracum is horny, and on the margins of the valves exhibits a very beautiful cellular appearance.

a. *Tunicata.*

The dermal covering of the *Tunicata* is composed of a thick flexible horny material somewhat resembling cartilage; it forms a case or bag, enclosing the entire body of the animal, which has only two small apertures of communication with the watery element surrounding it. When examined microscopically, it is found in certain species to consist of a dense structureless horny mass without any admixture or deposit of calcareous material; but in *Ascidia mammillata*, as stated by Wagner, minute crystals of carbonate of lime are to be met with; it would seem also from Preparations A p 92, 93, that in another but undescribed species of Tunicated animal, there exists a rudiment of a calcareous skeleton in the shape of masses of spicula, arranged in the form of a star, as represented in Plate XI. fig. 14; and the subjoined series of preparations will show the incorrectness of the statements that have been made, that the *Tunicata* are without any trace of shelly covering, as the rudiments of the same in the shape of calcareous spicula have been found in almost every specimen of Ascidian which has been submitted to microscopic examination in the preparation of this Catalogue.

The spicula are of minute size, and generally consist of a central portion or shaft with two stellate or trifid extremities, as shown in Plate XVII. fig. 13; they are dissolved with effervescence in dilute hydrochloric acid, and the animal matrix in which they were imbedded presents cavities of the same figure as the spicula. The nature of the horny integument is such, that the spicula cannot

be separated from it by boiling liquor potassæ; the only action that appears to take place is that of the integument becoming perfectly black.

A y 1. A portion of the outer surface of the integument of *Boltenia reniformis*, consisting of a dense horny substance, in which a large quantity of calcareous spicula are imbedded; they are of peculiar figure, and consist of a central portion or shaft with expanded bifid or trifid extremities; each spiculum measures on an average $\frac{1}{500}$th of an inch; they occur in the greatest abundance in the centre of the specimen, and their true shape cannot there be so satisfactorily made out as on the edges, where they are more widely diffused.

A y 2. A portion of the outer brown covering of the pedicle of the same *Boltenia*, in which calcareous spicula are very abundant, and the integument feels gritty to the touch. The spicula are of similar shape to those in the preceding preparation, but their situation is rather more superficial. Six specimens detached from the matrix are represented in Plate XVII. fig. 13.

A y 3. A portion of the outer brown covering of the pedicle of the same *Boltenia*, which has been treated with dilute hydrochloric acid in order to remove the calcareous spicula; the animal matrix remaining, presents perfect casts of the shape of the spicula, but in itself exhibits no trace of cellular structure.

A y 4. A portion of the outer integument of an *Ascidian*, which is of a horny nature, and contains numerous calcareous spicula; these are rather longer and more plainly seen than those in the three preceding specimens; each consists of a central portion or shaft having expanded extremities, four, five and six being the usual number of the rays, but in some few cases they are more numerous, and each extremity appears of a stellate figure. The average length of a spiculum is $\frac{1}{400}$th of an inch.

A y 5. A portion of the outer integument of the stalk of the same *Ascidian*, in which a great abundance of calcareous spicula are imbedded; they are of the same size and figure as those in the preceding specimen, and appear

to be arranged in a series of circles, from the various expanded extremities interlacing with each other, and leaving small clear spots somewhat like follicles in the middle.

A y 6. A vertical section of the horny integument of a large *Ascidian*, the thickness of which exceeds $\frac{3}{4}$ths of an inch; it contains no spicula, but the entire substance is traversed by numerous branching canals, some of them being empty, whilst others contain a series of brown granules. The outer surface of this specimen is of a dark brown colour, and very much resembles a potato in external appearance.

A y 7. A portion of the outer horny integument probably of a Tunicated animal, in which are imbedded numerous stellate calcareous spicula similar in shape to those represented in Plate XI. fig. 14; they vary much in size, and somewhat resemble those in certain sponges of the genus *Tethea*, but all the spicula in the sponge tribe that approach these in figure are composed of silica. *Presented by J. S. Bowerbank, Esq., F.R.S.*

b. *Brachiopoda.*

The calcareous skeleton or shell of these animals is generally speaking of small size, and composed, according to Dr. Carpenter, either of a plicated membranous or of a peculiar form of tubular tissue, which is characteristic of all the *Terebratulæ* both recent and fossil. When examined microscopically, as shown in Plate XVI. fig. 7, the outer surface of a thin horizontal section of a *Terebratula* presents little or no structure, except a series of large dark oval spots, as shown in figs. 7 and 8, presently to be described; if, however, the outer surface be removed, a prismatic or tubular structure, as shown at *b* in fig. 7, will be brought into view, the prisms running for the most part in parallel lines, and being slightly curved where the large black spots exist*. If the inner surface of a thin section of the same shell be examined, the black spots will still be seen, and all the tissue between them will present either a reticulated or an imbricated appearance, both being due to the inclination which the ends of the prisms have to the surface, so that where the prisms are nearly vertical to the inner surface, there the reticulations, shown at the lower part of fig. 8, are visible; but where they are more or less inclined, the imbricated appearance, shown at the upper part of the same figure, will be presented. In vertical sections of the same shell,

* Appendix H.

as shown in Plate XVI. fig. 9, the black spots, before alluded to, will be found to be perforations or large tubes running obliquely from the inner to the outer surface of the shell, the diameter of each being small at the former, and considerably dilated at the latter surface. In these tubes, as will hereafter be shown, certain cæcal appendages of animal membrane are situated. The perforations are present in all the recent *Terebratulæ*, except *T. psittacea*, but are absent in many of the fossil species; *T. psittacea*, however, has on other grounds been removed to the genus *Atrypa*. According to Dr. Carpenter, similar structures to those described in the *Terebratulæ* are present in some of the allied genera, as in *Orthis* and *Spirifer*.

When a portion of the shell of a *Terebratula* is treated with acid, the animal residue exhibits little or no trace either of a cellular or plicated arrangement, but appears nearly homogeneous; in this peculiarity the animal basis of the *Brachiopoda* differs from that of any other order of shells. If, however, the animal be contained in the shell, and the latter be subjected to the action of acid, a series of cæcal appendages attached either to the inner or outer membrane, as shown in Plate XVII. fig. 6, will be brought into view; these appendages lie in the perforations of the shell, and open on its inner surface: each one is connected with an oval disc, which appears to close the outer orifice of the perforation.

A y 8. A portion of the outer surface of the shell of a *Terebratula*, *T. rubicunda*, which has been rendered very transparent by grinding away its inner surface; it is of a red colour, and exhibits a series of dark oval spots (the upper extremities of the perforations), arranged in diagonal lines at nearly equal distances apart; the tissue between these presents little or no structure; but on careful examination, each perforation will be found to have a series of radiating lines or tubes on its outer margin, as shown at *a* in Plate XVI. fig. 7: this arrangement does not appear to have been hitherto described. On one edge of the specimen the outer layer has been removed, so that the colourless prismatic cells with the perforations can be plainly seen, as shown at *b* in the same figure.

A y 9. A portion of the inner surface of the same shell, which exhibits a reticulated and an imbricated arrangement; the former is presented when the cells lie nearly at right angles to the surface, the latter when they are either parallel or inclined at a considerable angle to it: between either of

these appearances the perforations may be seen; their diameter, it will be noticed, is much less than those on the outer surface. A portion of this preparation is represented in Plate XVI. fig. 8; at the lower part the reticulated structure is shown, and at the upper the imbrications.

A y 10. A portion of the outer surface of the shell of a small red undescribed species of *Terebratula*, exhibiting the perforations and numerous minute tubuli radiating from their upper extremities, similar to those described in Preparation A y 8. The entire shell was less than half an inch in length, and was sufficiently transparent to show all its peculiar points of interest without being ground on either surface.

A y 11. A portion of the inner surface of the same shell, exhibiting the perforations and the reticulated structure between them, both being on a smaller scale than those in *T. rubicunda*.

A y 12. A portion of the outer surface of the shell of *Terebratula Australis*, exhibiting the upper extremities of a series of large oval perforations, each having its radiating tubuli. The perforations are arranged in diagonal lines, and each one measures on an average $\frac{1}{400}$th of an inch in the long, by $\frac{1}{1000}$th in the short diameter.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 13. A portion of the inner surface of the same shell, exhibiting as many perforations as the preceding specimen, but their shape is circular, and their diameter only $\frac{1}{1200}$th of an inch; between them, however, the reticulated structure, caused by the mode of arrangement of the ends of the component cells, is well displayed.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 14. A portion of the shell of a fossil *Terebratula*, *T. bullata*, from the oolite; it exhibits a numerous series of perforations, but the structure between them is more or less smooth.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 15. A horizontal section of the shell of *Atrypa psittacea*, formerly belonging to the genus *Terebratula*; it exhibits a peculiar plicated arrangement, somewhat like that in the interior of many shells of the Terebratula, but

no perforations are present. A portion of this preparation is represented in Plate XVII. fig. 8. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 16. Two vertical sections of a fossil *Terebratula*, *T. inconstans*, each of which exhibits in all parts of its surface a plicated membranous structure, much coarser than that of the preceding specimen. A portion of one of these preparations is represented in Plate XVII. fig. 9.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 17. A vertical section of a large shell of *Terebratula rubicunda*, about $\frac{1}{16}$th of an inch in thickness, exhibiting the entire course of the perforations; these run in nearly straight lines from the inner to the outer surface of the shell, and in one or two instances are branched. The outer surface of the section may be readily known from the inner, not only by the red colour, but by the larger size of the perforations at that part.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 18. A vertical section of the same shell, taken from near the hinge; it exhibits many parts without perforations, but certain others, in which the perforations are very large or exceedingly tortuous; on either side of the hinge, a foramen about $\frac{1}{30}$th of an inch in diameter is situated; the inner margin of both presents the reticulated structure common to the interior of the shell, and from their upper sides numerous large perforations proceed as far as the circumference. The plications are large in many parts, and in others are so small and parallel, that under a power of 100 diameters they resemble the tubes of dentine. A portion of this preparation is represented in Plate XVI. fig. 9.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 19. An oblique section of the shell of *Terebratula Australis*, exhibiting the entire course of some of the perforations, and only a portion of others; all show very distinctly that the diameter of each perforation is much greater near the outer than the inner surface. In some parts the section has been made nearly at right angles to the perforations; in these the internal diameter may be readily measured.

Presented by Dr. W. B. Carpenter, F.R S.

A y 20. A portion of the animal basis of one of the valves of the shell of *Terebratula rubicunda*, after decalcification by acid. It consists principally of films of membrane, to one of which are attached a series of tubular cæcal appendages corresponding in size with the perforations in the shell. Each appendage is of a conical figure, the extremity attached to the most external or cuticular layer of membrane, as shown in Plate XVII. fig. 6, being the part answering to the base of the cone; this is more or less flattened or disc-shaped, and in some instances exceedingly minute radiating lines or tubuli, like those described in Preparation A y 8, and represented in Plate XVII. fig. 5, may be seen around their outer margin. The opposite extremity of the appendage is hollow, and opens on the internal surface of the shell, to the lining membrane of which, as shown in Plate XVII. fig. 7, it is attached. Under a magnifying power of 500 diameters, each appendage resembles a glandular follicle, being lined with minute cells; but the precise office it performs is at present a mystery.

A y 21. A portion of the membranous basis of the shell of *Terebratula caput serpentis*, exhibiting in some parts a minute cellular structure, but in others a surface nearly smooth, having cæcal appendages, similar to those described in the preceding preparation, attached to it; these last, however, are rather longer and smaller in diameter than those in *T. rubicunda*, but their cellular contents are more plainly displayed.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 22. A portion of the thin shell of a *Lingula*, *L. anatina*, consisting principally of horny matter of a beautiful green colour; in this, as shown in Plate XVI. fig. 16, numerous minute striæ or tubuli, like those of dentine, run in various directions, some being parallel, others nearly at right angles to the surface; between these is a series of round dots, which, under a power of 500 linear, are found to be the extremities of larger tubes that have been divided more or less transversely. In some parts of the preparation, however, it would at first sight appear that there are either two sets of tubes, or that one set is formed of striæ, as the transverse diameters indicated by the dots are far too large and not numerous

enough to have belonged to the more minute tubuli that abound in all portions of the surface of the specimen.

Presented by Mr. J. T. Norman.

A y 23. A portion of the shell of another specimen of *Lingula anatina*, in which the tubuli have been divided more or less obliquely, and in some parts may be traced after an undulating course to terminate in the dots before described; these tubes, however, are much larger than the striæ, and in a few cases both tubes and striæ are present together, the latter running at right angles to the former.

Presented by Dr. W. B. Carpenter, F.R.S.

c. *Lamellibranchiata.*

The shells belonging to this class of Mollusca are all bivalves, and, with very few exceptions, those animals having the lobes of the mantle disunited, inhabit shells exhibiting the prismatic cellular form of tissue, whilst those with the lobes partially or completely united present other kinds of structure, and their animal basis, instead of exhibiting a true cellular appearance, most frequently consists of a series of laminæ of a delicate membrane, and is small in quantity as compared with that of the earthy matter.

The best examples of the prismatic form of cellular tissue are found in the families *Ostraceæ* and *Margaritaceæ*, whilst the opposite condition is most strikingly manifested in those of *Cardiaceæ* and *Conchaceæ*.

A y 24. A transverse section of the shell of a *Pinna*, *P. nigrina*, exhibiting a honeycomb appearance, being composed of a series of hexagonal prisms of nearly uniform size, which have been divided in the direction of their short diameter. A portion of this preparation, in which the walls of the cells are sharp and well defined, is represented in Plate XVI. fig. 1: the average breadth of each prism is $\frac{1}{500}$th of an inch.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 25. A vertical section of the shell of the same *Pinna*, composed entirely of long prisms arranged in lines perpendicular to the surfaces of the shell; each prism is of hexagonal figure, and has pointed extremities, one or both of which, as shown in Plate XVI. fig. 2, may be occasionally

seen in the same section. The colour of the shell is more or less purple, and all the prisms are marked with transverse striæ.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 26. The animal basis of a transverse section of the shell of the same *Pinna*, exhibiting appearances nearly similar to those of the shell before decalcification; the principal points of difference however are, that in this specimen the walls of the cells are not so thin and sharp, and in each prism a film of membrane like the remains of a nucleus is visible. A portion of this preparation is represented in Plate XVI. fig. 5.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 27. The animal basis of a vertical section of the same *Pinna*, which presents precisely similar appearances to those described in Preparation A y 25; the transverse markings and the pointed extremities of the prisms are very well displayed. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 28. A series of prisms obtained from a dark fossil *Pinna*, in which the animal matter was undergoing decay, and the component prisms by very gentle force could be detached from each other; all exhibit the transverse striæ very distinctly, but only a few of them have pointed extremities.

Presented by Frederick Wood, Esq., M.R.C.S.E.

A y 29. A series of larger prisms of a fossil *Pinna* from the Chalk, all of which exhibit very beautifully the transverse markings, and very many have either one or both extremities pointed. Portions of three prisms are represented at *b* in Plate XVI. fig. 4 under a power of 70 diameters: their figure as there shown is hexagonal; a portion of another larger specimen, in which the transverse striæ are well marked, is represented at *a* in the same figure. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 30. A transverse section of a large shell of *Pinna ingens*, exhibiting, in addition to the ordinary reticulated structure, a series of small very black cells; these are found in the greatest number on the natural outer surface of the shell; the dark appearance of the cells is not confined to this species of shell, but is occasionally met with in other genera, as may be

seen in Preparations A y 36, 38. A portion of this preparation is represented in Plate XVI. fig. 3. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 31. A thin natural lamina of a species of *Pinna*, exhibiting a large nucleus in the centre of each cell; a portion of this preparation is represented in Plate XVII. fig. 2.

A y 31*. Fragments of a vertical section of *Pinna rudis* after decalcification by acid; in some parts they exhibit the structure of the prisms and their transverse striæ, but in others the membrane has split in the direction of the striæ, proving that the prisms are made up of a series of cells of the same shape as their transverse section. A portion of this preparation is represented in Plate XVII. fig. 20.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 32. A horizontal section of the shell of *Perna ephippium*, exhibiting a reticulated structure of very much smaller size than that of any of the *Pinnæ*; the diameter of the cells being on an average $\frac{1}{1200}$th of an inch. In this shell, as in *Pinna*, the internal layer consists of true *nacre*.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 33. A horizontal section of the shell of *Malleus albus*, exhibiting a reticulated structure remarkable for the variable size of the cells of which it is composed; in one portion of the surface, in immediate connexion with the nacreous layer, the cells are as small as $\frac{1}{2000}$th of an inch, whilst in others not far distant they even exceed $\frac{1}{300}$th of the same quantity.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 34. A horizontal section of the same shell, in which three distinct kinds of structure are visible; the first may be described as consisting of the large cells, the second of the minute ones, and the third of the nacreous layer, in which last are situated numerous large branching tubuli running in various directions. The wavy structure of the nacre itself is very well shown. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 35. A horizontal section of a shell of the genus *Crenatula*, exhibiting on its upper surface a layer of hexagonal cells like those in some of the pre-

ceding preparations, but on its under surface a nacreous layer traversed by wavy lines. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 36. A horizontal section of the shell of *Avicula margaritifera*, exhibiting a reticulated structure composed of hexagonal cells similar to those described as occurring in *Pinna ingens*, and like them, also, having some of small size and of a more or less black colour. On the inner surface of the walls of some of the large prisms transverse striæ may be seen, as represented in Plate XVI. fig. 6. *Presented by Mr. J. T. Norman.*

A y 37. A vertical section of the same shell, in which to the naked eye two distinct kinds of structure are visible; the one of a brown colour, consisting of a row of short prisms pointed at both ends and having transverse striæ; the other of a thick layer of *nacre*, exhibiting its characteristic colours and wavy markings. *Presented by Mr. J. T. Norman.*

A y 38. A horizontal section of a shell of the genus *Vulsella*, remarkable for exhibiting a very minute reticulated structure, composed of cells of nearly uniform size, which measure on an average less than $\frac{1}{2300}$th of an inch in diameter; as in *Pinna ingens* a few black cells occasionally occur amongst the others. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 39. A thin lamina of a small transparent Oyster, consisting of a series of short hexagonal prisms resembling flattened cells; in many of which, under favourable circumstances, a small delicate nucleus may be seen. A portion of this preparation is represented in Plate XVII. fig. 10.

A y 40. A thin section of the shell of the common Oyster, *Ostrea edulis*; in some parts it exhibits the prismatic cellular structure, the prisms being inclined at different angles to the surface; in other parts the hexagonal cells only are visible.

A y 41. A thin layer of calcareous matter of a brown colour, taken from the outer surface of a common *Oyster*; it exhibits in some parts the usual reticulated structure, but on the edges (especially that nearest the name) a series of minute rhombohedral crystals of carbonate of lime are visible; some of them are as small as $\frac{1}{8000}$th of an inch, whilst others

even exceed $\frac{1}{2000}$th of the same quantity. A portion of this preparation is represented in Plate XVI. fig. 14. On the margins, the crystals are more or less separated from each other; but nearer the middle they form a connected layer. It would appear that in this layer of shell, the carbonate of lime, instead of being deposited in a uniform manner in the interior of cells, has been secreted upon a plain membrane, and assumed the crystalline form.

A y 42. A horizontal section of the outer layer of the shell of a common *Oyster*, exhibiting the prismatic cellular structure; the walls of each prism being more or less rounded by the large amount of animal matter deposited between them. A portion of this preparation is represented in Plate XVI. fig. 13.

A y 43. A horizontal section of the inner portion of the shell of the common *Oyster*, exhibiting on the greater part of its surface a peculiar structure somewhat like nacre, which makes up the principal mass of the shell; on one of its outer margins the ordinary prismatic structure may be seen.

A y 44. A horizontal section of the shell of *Pandora rostrata*, exhibiting a structure very like that of the preceding specimen; the greater part of the surface is composed of a *nacre*-like substance, in which are numerous branching tubuli running in various directions; these, when divided transversely, appear to be surrounded by a transparent margin; minute undulating lines characteristic of nacre are found upon all parts of the surface of this portion of the preparation. On the lower edge, however, true prismatic cellular structure is present, as in the Oyster.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 45. Two portions of the external surface of the shell of *Anomia ephippium*; the larger exhibits on one of its margins a trace of the reticulated structure, but in all other parts nothing but branching tubuli are visible; these, however, are best seen in the smaller specimen, and their diameter, on measurement, is found in some cases to exceed $\frac{1}{5000}$th of an inch.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 46. A horizontal section of the shell of another specimen of *Anomia ephippium*, composed entirely of a subnacreous tissue, on one edge of which, branching tubuli larger than those of the preceding specimen are situated; some of them appear empty, but others are full of dark granular matter; the largest specimens measure $\frac{1}{4000}$th of an inch in diameter. A small portion of this preparation, showing a few of the tubuli, is represented in Plate XVI. fig. 19. *Presented by Mr. J. T. Norman.*

A y 47. A horizontal section of the external surface of a shell of the genus *Spondylus*, exhibiting in the coloured portion a peculiar fibrous looking structure; but near the upper edge of the specimen the white internal part is visible; in this there are numerous minute striæ and an appearance of prisms pointed at both extremities. This layer is traversed at right angles by numerous tubuli.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 48. A horizontal section of a portion of a shell of *Lima scabra*, consisting principally of a subnacreous layer, in which large branching tubuli are very abundant; they are not arranged in any definite order, but cross and recross each other in various directions; near the centre of the specimen there is a brown part rather more opaque than the rest; in this the prismatic cellular structure is distinctly visible. A portion of this preparation is represented in Plate XVII. fig. 21.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 49. A horizontal section of the surface of the shell of *Unio occidens*, consisting principally of prismatic cellular tissue, the prisms being arranged at various degrees of obliquity with the surface; on the upper and under margin of the specimen, portions of the brown horny *periostracum* may be seen: they present little or no structure, but the prisms over which they lie are much smaller than those in any other part of the surface.

A y 50. A horizontal section of another shell of *Unio occidens*, in which the prismatic cellular structure is well shown; on the upper margin, a small portion of the periostracum remains; upon this a few hexagonal cells are situated: these are remarkable for being detached from each other in

certain places, and many of them have a dark deposit in their interior, which appears to be produced by the growing inwards of an offset from the cell wall; in others the dark deposit occupies the centre of the cell, and is wholly unconnected with the margin. In all the shells of this family the horny periostracum is present, and the prismatic cellular structure is found only in a thin layer beneath it, the principal part of the shell being composed of *nacre*.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 51. A vertical section of the lip of the shell of *Unio occidens*, exhibiting both the prismatic cellular and the nacreous structure; the former, as represented in Plate XVI. fig. 26, entirely overlaps the latter, so that unless the lip be fractured no portion of nacre is ever found on the edge of the shell. A corresponding arrangement of parts occurs in the Oyster; but in this animal the nacreous and prismatic layer are not so intimately connected together.

In all the shells now described the prismatic cellular structure exists as a constant character, and the animal basis is in such abundance as to retain the original shape of the section after the removal of the calcareous material. In these shells also examples have been afforded of a *periostracum* and of a nacreous and subnacreous layer, both being occasionally traversed by branching tubuli: in all such shells, as stated in page 274, the lobes of the mantle are unadherent. But in the following series of preparations, made from shells having the lobes of the mantle either partially or completely united, a different arrangement will generally be found; the true prismatic cellular tissue will be rarely met with, and the animal basis, from being so small in quantity, will appear only as a thin membrane after the removal of the calcareous material. Many examples will also be given in which the calcareous element has assumed somewhat of a crystalline form.

A y 52. A portion of the epidermic layer of *Mytilus edulis*, consisting principally of a brown horny periostracum in which but little structure can be observed: this overlies a thin layer presenting a minute cellular arrangement; the cells being in some parts quite transparent, but in others of a black colour, probably from their containing a small amount of air.

On the under surface of the specimen there is an indication of a nacreous structure, an iridescent colour, and a series of minute striæ being present. A portion of the cellular layer is represented in Plate XVI. fig. 10. Amongst the more transparent cells may be seen others that are black; in these the cell wall is not very distinctly shown.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 53. A horizontal section of the outer surface of the shell of *Mytilus edulis*: the central portion is of a blue colour, and exhibits only a faint indication of prismatic structure: two of the margins are covered by periostracum, presenting a distinctly cellular appearance.

A y 54. A horizontal section of the inner surface of the same shell, exhibiting the blue coloured layer and another somewhat like nacre in its structure: of this last, nearly the whole thickness of the shell is made up.

A y 55. A horizontal section of the shell of *Arca Noæ*, exhibiting a considerable amount of tubular structure: the tubuli commence on the inner surface of the shell between the ribs, and pass outwards in a diverging manner; their diameter on an average measures $\frac{1}{6000}$th of an inch. The basis of the shell presents no trace of prismatic cellular tissue, although in certain parts there are plications very much resembling it: these, however, correspond to the ribs.

A y 56. A horizontal section of the shell of *Cardium cardissa*, exhibiting in those parts of its surface corresponding with the ribs of the shell, an appearance very like the prismatic cellular structure; but in all the remaining parts a fibrous arrangement is visible; both, however, are traversed by tubuli, which vary considerably in size.

A y 57. Another horizontal section of the same shell, which has been reduced so much in thickness as to exhibit only a very slight indication of the position of the ribs; the basis presents a more or less fibrous appearance, and the tubuli, from running principally in the plane of the section, are very well seen; they are, however, of small size and not very numerous. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 58. Three sections of a fossil shell known as *Pleurorhynchus Hibernicus*, formerly classed with the *Cardiaceæ*, from its resemblance in form to certain species of that family; but which, as suggested by Dr. Carpenter, ought more properly to be referred to the group of *Rudistes*; they all exhibit the structure termed *cancellated*: the cancelli are formed of planes intersecting each other nearly at right angles: in these sections they are entirely filled up with carbonate of lime.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 59. A horizontal section of the shell of a species of *Amphidesma*, belonging to the family *Mactraceæ*, in certain parts of which distinct traces of prismatic cellular structure are visible; in the same preparation are certain small fragments, appearing to have been removed from the outer surface of the shell; these consist entirely of rows of prisms placed one over the other; each prism exhibits a radiated fibrous structure: this arises from the calcareous material within it being arranged in a crystalline form.

A y 60. A horizontal section of the shell of *Trigonia Lamarckii*, exhibiting in some parts a very thin layer of more or less rounded cells, like those described in Preparation A y 52; beneath this is a layer of nacre having occasionally a few very minute tubuli in its substance.

A y 61. A portion of a delicate membrane removed from the outer surface of the same shell, being closely connected with the periostracum; it consists of a series of very beautiful hexagonal nucleated cells, varying much in size and provided with very thick walls. This membrane has been termed the periostracum by Mr. Bowerbank; but Dr. Carpenter states that it is a layer situated immediately underneath it. A portion of this preparation is represented in Plate XVI. fig. 11.

Presented by J. S. Bowerbank, Esq., F.R.S.

A y 62. A horizontal section of the shell of *Mya arenaria*, exhibiting in one portion of its surface a distinctly cellular structure; from this part to the centre, the cell walls become less and less evident, until at last

nothing is left to indicate their presence but the dark granular matter contained in their interior. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 63. A vertical section of the hinge-tooth of the shell of *Mya arenaria*, composed of a series of rows of short prisms, in some of which, as shown in Plate XVII. fig. 14, a fibrous or crystalline appearance is exhibited.

A y 64. Two horizontal sections of the same tooth, in which the prisms are divided in a direction at right angles to their length, so that a cellular structure results; many of the large cells present a remarkable appearance like that of a mineral termed Aragonite, from the calcareous material within them being arranged in a radiated form. One portion of this preparation is represented in Plate XVII. fig. 15, and another in fig. 16.

A y 65. A horizontal section of the shell of *Anatina olen*, in the margins and centre of which a distinct cellular structure is visible, all the other parts of the section being occupied by a tissue somewhat resembling nacre; like some of the preceding specimens, this is traversed by very minute tubes. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 66. A horizontal section of the shell of *Thracia distorta*, on the edges of which the cellular character is very distinctly seen; the walls of the cells are there very plainly shown, and in the centre of each of the larger cells numerous dark granules occur; these have been regarded as the remains of the nucleus. The central portion of the specimen exhibits no trace of prismatic cellular structure, but like the nacreous layer of some other shells, is traversed by branching tubuli: although the presence of cells is so evident in this specimen, yet, when treated with acid, no trace of them can be discerned. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 67. A horizontal section of the shell of *Thracia convexa*, exhibiting on the margin nearest the name, a large quantity of polygonal cells, some of which are of very large size; these last are sections of certain tubercles projecting from the outer surface of the shell, which in the recent state were covered by periostracum. All the smaller cells present precisely the same characters as those in the preceding preparation.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 68. A horizontal section of the shell of *Myodora striata*, the external surface of which exhibits numerous large polygonal cells; these are found to be the ends of short prisms, arranged somewhat obliquely to the surface of the section; both the cells and the prisms contain calcareous material, arranged in a radiated or crystalline form.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 69. A horizontal section of the inner surface of the same shell, exhibiting a nacreous structure, which in a few parts is traversed by minute tubes, and in others presents dark granular spots like those found in the centre of some of the cells. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 70. A horizontal section of the outer surface of the shell of *Schizzodesma nitida*, exhibiting an indistinct cellular structure, the cells being of very much smaller size than those in any of the preceding specimens; on the margins of the section, portions of the internal layer are visible; these are all composed of structureless material. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 71. Two vertical sections of the hinge-tooth of *Pholas crispata*, each of which exhibits a distinct cellular structure; the cells vary considerably in size, and in all the larger specimens the cell wall is faintly seen; but their centre is occupied by a stellate mass of dark granules like a nucleus. This portion of the specimen is represented in Plate XVI. fig. 17, and is seen to the greatest advantage in the section having the angular margin; in the other, which is of an oval shape, the cells are much smaller, and nearly half of its surface is occupied by minute cells completely full of black matter. *Presented by Mr. J. T. Norman.*

A y 72. Two horizontal sections of the external layer of the shell of *Solemya australis*, one with its outer, the other with its attached surface upwards; both exhibit a distinct prismatic cellular structure, the prisms lying nearly parallel with the surface; they are, however, small and sharp pointed. On the margin of each section, the brown horny epidermis is plainly seen*. *Presented by Dr. W. B. Carpenter, F.R.S.*

A y 73. Two portions of the *periostracum* of a shell of a species of *Glycimeris*,

* The animal matter of this shell retains the cellular character after decalcification.

both of which clearly exhibit a series of very minute cells of hexagonal figure; but whether these belong to the periostracum itself, or to a layer beneath, it is difficult to say. In this particular the periostracum of *Glycimeris* resembles that of *Trigonia*, *Anatina* and *Mytilus*.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 74. A horizontal section of the shell of *Cleidothærus chamoides*, exhibiting in all parts that to the naked eye appear opaque, a distinctly cellular structure, the cells being mostly full of dark calcareous matter, somewhat in the form of crystals. All the other portions of the surface present a nacreous structure in which large tubuli occur; near the centre of the preparation a triangular hole may be observed; around the margin of this many of the tubuli appear to commence: some of them are divided transversely, whilst others ramify in the nacreous substance.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 75. A vertical section of a fossil shell termed *Hippurite*, belonging to the extinct group of *Rudistes*, nearly the whole thickness of which is composed of *cancellated* structure; it exhibits a series of short broad prisms of hexagonal figure, terminated by flattened partitions, each prism being full of calcareous material in a crystalline state. A portion of this preparation is represented in Plate XVI. fig. 20.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 76. Two horizontal sections of the same *Hippurite*, exhibiting the shape of the prisms composing the cancelli; this is more or less hexagonal, their walls being thick and well-defined; some of them are full of dark granular matter, others of transparent crystals. A portion of one of the sections is represented in Plate XVI. fig. 21.

Presented by Dr. W. B. Carpenter, F.R.S.

d. *Gasteropoda.*

The animals comprising this class are very numerous; they differ from all those previously described in being provided with a fleshy disc, serving as a foot, upon which they creep. The back is covered with a cloak, in or upon which the shell is secreted; this may consist of one or many pieces, or, as in certain of the Nudibranchiate order, may be either absent or represented by small calcare-

ous spicula, somewhat resembling those found in the *Gorgoniæ*. All the shells are remarkable for the small amount of the animal, as compared with that of the earthy matter, so that they are extremely brittle, and their fractured surfaces have a crystalline appearance; the term *porcellanous* was applied to them by Mr. Hatchett in consequence of the animal basis being so small in quantity as only to be satisfactorily recognised by its becoming black when heated.

For our knowledge of the intimate structure of the shells of *Gasteropoda*, we are principally indebted to Mr. Bowerbank. When thin sections of the larger specimens are examined by transmitted light, no correct idea can be formed of their structure; but when fractured surfaces are viewed by light reflected on them by a Lieberkuhn, the mode of arrangement of their several parts is clearly brought out. All the members of the Pectinibranchiate order are found to be made up of three layers, each consisting of innumerable plates composed of elongated prismatic cellular structure disposed alternately in contrary directions, so that the row of cells in one layer intersects that below it nearly at right angles: according to Mr. Bowerbank, the rows are inclined to the surfaces of the shell at an angle of 22°, as shown in Plate XVI. fig. 15; and in all cases the outer and inner layer have the same direction; this is either parallel or at right angles to the lines of growth; the middle one however is always arranged so as to be at right angles to the other two layers; hence, as stated by Dr. Carpenter, "if a horizontal section of the surface of the shell be made it will cut the edges of the component laminæ, but if the section be at right angles to the last and pass through the middle layer in the plane of its laminæ, it will cut through the edges of the laminæ making up the interior and exterior layers; whilst if the section traverse the two latter in the plane of their laminæ, it will cut across the laminæ of the middle layer."

There are however some shells in which this mode of arrangement is slightly departed from, a few examples of which will be included amongst the specimens presently to be described; but however much the crystalline appearance may prevail in certain large shells, it can be shown in nearly every case, even in the adult state of the shell, that they were formed originally of cells; the strongest evidence in favour of this view is afforded by the examination of those parts of shells in which growth is proceeding; this, as will hereafter be described, always takes place through the agency of cells.

A y 77. A horizontal section of a shell of the genus *Cypræa*, including portions of all three of its component layers; these may be readily distinguished from each other in the lower transparent part of the preparation, as the direction of the prismatic cellular structure in the outer and inner layers is at right angles to that found in the centre of the specimen, which belongs to the middle layer; if, however, the upper more opaque margin of the section be examined, the prismatic cellular structure may be traced all across the surface; a circumstance arising from no portion of the middle layer being visible at this point.

A y 78. A horizontal section of the same shell, taken principally from the inner surface; it exhibits a somewhat similar arrangement to that described in the preceding preparation, the prismatic cellular structure in the centre being arranged at right angles to that either on the outer or inner surface. In one part of this section there is an appearance of a nacreous layer.

A y 79. A portion of the shell of *Cypræa mauritiana*, fractured in the vertical direction or at right angles to the lines of growth; it exhibits three distinct strata, each of which, according to Mr. Bowerbank*, is formed of innumerable plates of elongated prismatic cellular structure, each plate consisting of a single series of parallel oblong cells. The plates are disposed alternately in contrary directions, so that one series of cells intersects that beneath it nearly at right angles, and all of them are so disposed as to form angles of about 22° with the upper and under surfaces of the shell. A small portion of the central stratum is represented in Plate XVI. fig. 15. The planes of the plates of prismatic cellular structure are always nearly parallel or at right angles to the lines of growth, and the mode of arrangement is such that the prisms in one layer are always opposed to those of the layer either above or beneath it.

Presented by J. S. Bowerbank, Esq., F.R.S.

A y 80. A horizontal section of a shell, of the genus *Strombus*, exhibiting a distinct prismatic cellular structure, the prisms being arranged in rows,

* Transactions of the Microscopical Society, vol. i. p. 128.

and those in one row are situated nearly at right angles to those in the two adjoining rows ; the prisms are crossed by a series of minute white curved lines, indicating the stages of growth ; they are most numerous on the convex margin of the preparation, where the prisms are the smallest.

A y 81. A horizontal section of the shell of *Haliotis splendens*, composed of alternate wavy bands of a brown horny material and of *nacre* ; the latter may be readily distinguished from the former, not only by its colour, but by the peculiar undulating lines seen on its surface ; these have been before alluded to, and a few of them are represented at *a* in Plate XVI. fig. 25 ; in immediate connection with the nacreous layer may be seen the horny material, having its surface covered with hexagonal cells of various sizes, each being provided with a coloured spot of a stellate figure in its centre, as shown at *b* in fig. 25. These cells form a very thin layer, and in many parts the nacre can be seen immediately underneath them. Under a power of 100 linear, the nacre presents a dotted or granular appearance, but under one of 500 a minute cellular structure is occasionally visible. *Presented by Mr. J. T. Norman.*

A y 82. A vertical section of the shell of *Haliotis splendens*, consisting of alternate curved bands of horny matter and of nacre, the former on an average being no more than $\frac{1}{40}$th, whilst the latter often measures $\frac{1}{10}$th of an inch in thickness ; the margins of the horny matter have a more or less indented appearance, arising no doubt from the presence of the peculiar cells described in the preceding specimen. All portions of the nacre have minute dark lines like tubuli passing across them in a direction at right angles to their length ; they are of uniform diameter throughout, and cannot be said to branch : on this account they might be considered as scratches in the shell, but they are not confined to the surface.

A y 83. A portion of the animal basis of the shell of *Haliotis splendens*, consisting of two distinct kinds of structure, the one of a green colour, the other beautifully iridescent ; the former consists of a structureless membrane, having the colour uniformly distributed through it, whilst the latter

is more or less plicated, as shown in Plate XVII. fig. 18, but not altogether structureless, as under a power of 250 diameters its surface is minutely dotted. The green-coloured membrane is the horny element, whilst the other belongs to the nacre; the colouring matter of the former, however, was soluble in the acid employed to decalcify the fragment of shell. It may be remarked in this preparation that where the membrane is plicated it is highly iridescent, but where the plicæ have been disturbed the colour has disappeared.

A y 84. A portion of the nacreous layer of another specimen of *Haliotis splendens*, detached from the horny material; in some parts it is beautifully iridescent, in others colourless; when carefully examined, it will be found that where the colour is, there the membranous basis is more or less plicated; in all the colourless parts it is nearly smooth, and in a favourable condition for exhibiting its ultimate cellular structure.

A y 85. A horizontal section of one of the calcareous plates or teeth from the gizzard of *Bulla lignaria*; it is of a triangular figure, and exhibits a distinct prismatic cellular structure, as shown in Plate XVII. fig. 22.

A y 86. Five horizontal sections of the shell of a small species of *Natica*, each of which exhibits on its surface a peculiar variety of cellular structure, the cells being of irregular size and perfectly black, and very much resembling those of certain forms of pigment; beneath this layer a distinct prismatic cellular structure is visible: a few of the prisms having been detached from the general mass are now to be seen in different parts of the specimen lying loose in groups of two or three together. The prisms are of small size, and in the generality of cases are sharp at both extremities. The coloured cells occur in the middle layer.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 87. A horizontal section of the external surface of the shell of a species of *Chiton*; some parts of the specimen are tinged with green colouring matter, and the superficial portions appear to be of a fibrous nature, the direction of the fibres being parallel with the surface. The upper part of the section is perforated by large canals, which pass down ob-

liquely towards the middle layer, but do not penetrate it. Deeper down, or on the under surface of the part containing the tubes, a layer of small cells may be seen, and still deeper another layer of much larger cells; below these the fibrous structure again occurs.

A y 88. A portion of the outer surface of the integument of a Nudibranchiate Mollusk, probably of the genus *Doris*, in which are contained numerous flattened calcareous spicula of fusiform figure, having both extremities slightly rounded; these may be considered as the rudiment of the shell. A small group of the spicula is represented in Plate XVI. fig. 12.

Presented by J. S. Bowerbank, Esq., F.R.S.

A y 89. A horizontal section of an *operculum* of a large *Turbo*, composed of a series of minute prisms, the contents of which exhibit a radiated crystalline structure; the prisms are crossed by an infinite number of curved lines; some of these appear as lines of growth, whilst others are as close together as those in the prisms of the large *Pinna*, represented in Plate XVI. fig. 4 *a*. The edge of the specimen opposite the number presents the most curious structure, there being in this situation a row of large cones, showing very plainly the radiated disposition of the calcareous matter. This section very much resembles that of the *Strombus* described in Preparation A y 80.

A y 90. A vertical section of the same *operculum*, in which, by means of the naked eye, two curved rows of small foramina may be observed; one of these is situated near the upper surface of the specimen, the other near the middle; all the parts of the shelly substance in the neighbourhood of the foramina exhibit traces of prismatic cellular structure, but almost all the others are occupied by the curved lines of growth.

e. *Pteropoda.*

The Pteropoda are animals of small size, having no foot or other apparatus for creeping or for fixing themselves to the bottom of the sea, but whose organs of locomotion consist of two muscular expansions in the form of fins, by means of which they swim freely in the waters of the ocean. Some species, as the *Clio*, are naked, whilst others have either a cartilaginous envelope or a very

delicate transparent shell; this is in some instances single, but in others composed of two or more pieces in the form of valves; these, however, are not capable of being opened as the ordinary bivalve shells, but are so firmly fixed as to be separated only by gentle force.

The microscopic structure of these shells, constituting as they do the skeleton of the Pteropoda, is extremely simple; some of them are as transparent as glass, and present no trace of prismatic cellular structure, the only markings observable on them being the curved lines of growth; those that are thicker have a granular appearance on the outside and a fine subnacreous layer within.

When the calcareous matter has been removed by acid, the animal basis appears to consist of little else than a series of laminæ of structureless membrane; in some few instances however, several very minute prismatic crystals, insoluble in dilute hydrochloric acid, may be seen attached to the membrane.

A y 91. A portion of the shell of a small Pteropod of the genus *Cavolina*, consisting of a thin layer of calcareous material quite as transparent as glass; it exhibits no structure except that of the curved lines of growth.

A y 92. A portion of the shell of another Pteropod of the genus *Cavolina*; it is rather thicker than the preceding specimen, but exhibits no other markings than those indicating the lines of growth.

A y 93. Two portions of the shell of another Pteropod, probably of the genus *Clione*; both are of an opaque white colour, and exhibit on their outer surface a granular structure in addition to the lines of growth, but on the inner surface a trace of a nacreous layer is very evident.

A y 94. A portion of the shell of a larger Pteropod of the genus *Clione*; it is of a light brown colour, and exhibits on its outer surface a vast number of curved lines of growth; its minute structure is granular.

A y 95. A portion of the same shell, having its inner concave surface uppermost; this presents an iridescent appearance, caused by the presence of a thin layer of nacre, in which the characteristic structure is very plainly exhibited.

A y 96. A portion of a conical shell of a Pteropod, probably of the genus *Creseis*; it presents on its outer surface a series of elevated ribs, which are very

visible to the naked eye; the shell itself, although exceedingly thin, is nevertheless not very transparent; it consists of two layers, the outer being more opaque than the inner; the structure of the former is minutely granular, but that of the latter somewhat fibrous, and all the fractured edges exhibit a thin film of fibres projecting beyond the outer granular layer.

A y 97. A portion of the thin tubular shell of a Pteropod, *Triptera columnella*, appearing to the naked eye quite as transparent as glass, but which, when examined with a power of 250 linear, exhibits a minutely granular structure.

f. *Cephalopoda.*

The *Cephalopoda* are not only the most highly organized members of the Molluscous sub-kingdom, but also of all the invertebrate animals. Their skeleton is situated in some cases external, in others internal to the soft parts, and is composed either of a shell of hard calcareous material, or of a thin lamina of horn. Some of the shells consist of many chambers, as that of the *Nautilus* and *Spirula*; others of only one chamber, as the *Argonaut*; while the *Sepiostaire* of the Cuttle-fish, the *pen* or *gladius* of the *Calamary*, and the *style* of the *Octopus* are representatives of the shell in its most rudimentary condition.

However much the shells of the Cephalopoda may resemble those of the other Mollusca in general appearance, they do not afford the best evidence of the near approach of these animals to the Vertebrata, but the existence of an internal skeleton composed of many pieces of firm cartilage, and supporting the principal organs of the body, brings them into close connection with the lowest of the cartilaginous fishes*. The intimate structure of the skeleton of the Cephalopoda, as would *à priori* be imagined from the variety of forms under which it is found, does not present a single constant character; therefore it would be impossible to give any description that would apply to the whole class: on this account the preparations from the same animal must be considered as complete in themselves.

A y 98. A transverse section of the *Style* of an Octopus, *Octopus vulgaris*, consisting of concentric layers of brown horny material; the central portion is of a dark brown colour, and the others are nearly white.

* Specimens of the cartilage of *Sepia officinalis* are described at page 102.

A y 99. Transverse sections of the *Pen* or *Calamus* of a Loligo, *Loligo vulgaris*, each of which resembles a *fleur-de-lis* in shape, and is composed of dark brown horny material, in which the laminated arrangement is very plainly exhibited.

A y 100. A transverse section of the "spathose guard" of a *Belemnite*, consisting of long prismatic cells arranged in a radiated form; these are traversed by the concentric lines of growth, which are very visible to the naked eye, there being nearly a hundred in this section. A segment of this preparation is represented in Plate XVIII. fig. 10, under a power of 30 diameters, and a portion of the same more highly magnified in fig. 11.

Presented by Mr. J. T. Norman.

A y 101. A vertical section of the "spathose guard" of the same Belemnite, exhibiting the prisms divided in the direction of their short diameter: each one is of a more or less hexagonal figure, and shows very plainly the parts in which the lines of growth intersect it.

A y 102. A transverse section of the "guard" of another *Belemnite*, in which the lines indicating the walls of the radiating prisms are more evident than the concentric lines of growth.

A y 103. A transverse section of the shell (*Sepiostaire* or *Cuttle-bone*) of a Cuttle-fish, *Sepia officinalis*, consisting of a series of curved laminæ, separated from each other by thin wavy partitions or pillars of calcareous material, marked with transverse lines, which, to a certain extent, resemble those of the prisms of some species of *Pinna*. In this specimen there are seventeen curved laminæ, each separated by the partitions before alluded to. If the partitions be carefully examined, it will be found that each row is traversed by a series of very fine transverse markings; these are best seen where the pillars are absent; they appear to form the walls of certain cells or septa that occupy all the spaces between the pillars.

A y 104. A transverse section of the *Sepiostaire* of another Cuttle-fish, in which there are no less than nineteen curved laminæ, separated from each other by thin undulating films of transparent calcareous material; the distance between the laminæ being much greater in this than in the preceding

specimen, the transverse striæ of the partitions are in consequence more widely separated. A portion of this preparation is represented in Plate XVIII. fig. 16, and it may be noticed that the ends of all the pillars on the concave side of the laminæ are broader than those on the convex; in order to show this fact a single pillar has been represented in fig. 17; the lower end of this was attached to the convex surface of the lamina, and the upper to the concave.

A y 105. A longitudinal section of a portion of the *Sepiostaire* of the same Cuttle-fish, including one of the laminæ and many of the pillars attached to it. When viewed with a power of 100 linear, the pillars will be found to project from the lamina, and from being seen edgeways their true nature can be ascertained; they therefore may be described as consisting of a thin layer of calcareous material, folded or plaited like a frill. If the pillars be broken away their shape is still shown by the lamina, upon both surfaces of which they leave their impressions, as represented in Plate XVIII. fig. 18; this perhaps will give a better idea of their figure than any written description. The lamina itself presents a granular appearance, and is much more opaque than the pillars. In this preparation the concave side of the lamina is uppermost.

Presented by T. S. Ralph, Esq., M.R.C.S.E.

A y 106. A horizontal section of another portion of the same *Sepiostaire*, in which the convex surface of the lamina is uppermost: in this specimen it may be seen that the markings of the pillars upon the lamina are much smaller and less undulating than those of the upper edges of the pillars themselves. *Presented by T. S. Ralph, Esq., M.R.C.S.E.*

A y 107. A portion of the outer hard calcareous shell of a Sepiostaire, which is composed principally of hexagonal cells of large size, each having a large nucleus of an oval figure; this appears as a centre of ossification, and from it numerous radiating lines, like those of crystallization, are given off. A portion of this specimen is represented in Plate XVIII. fig. 15, and to avoid confusion, only a very few of the radii are shown.

A y 108. A portion of the outer surface of the shell of a *Spirula*, *Spirula australis*, which presents, even to the naked eye, a rough appearance; when examined

microscopically, this is found to be due to a coarse reticulated tissue, the reticulations being slightly raised above the general surface; in some parts the markings correspond to those of the laminæ of the Cuttle-fish before described. The interspaces and the reticulations themselves are covered by a semi-transparent granular layer of a brownish colour. A portion of this preparation is represented in Plate XVIII. fig. 14, and the shell itself is shown at *a* in the same figure.

A y 109. A portion of the inner surface of the shell of the same *Spirula*, exhibiting a distinct cellular layer like that in the Oyster or Pinna; between this and the granular coating of the outer surface, may be seen the coarse reticulated tissue. A few of the cells are represented in Plate XVIII. fig. 19.

A y 110. A portion of one of the transverse partitions of the same *Spirula*, exhibiting a delicate nacreous structure.

A y 111. A vertical section of the shell of *Nautilus Pompilius*, consisting of a thick internal layer of *nacre*, having an investment of opaque cellular material. This specimen is represented in Plate XVIII. fig. 13; and at *a* is shown a portion of the cellular layer magnified 500 diameters.

A y 112. A portion of the *nacre* of the same shell decalcified by acid; it exhibits in a well-marked manner the cells of which this structure was formed. A portion of it is represented in Plate XVII. fig. 19.

A y 113. Three portions of the shell of an Argonaut, *Argonauta Argo*, composed of brittle calcareous material, exhibiting a minutely granular structure, but no trace of cells; the surface however is covered with minute cracks, giving to it somewhat of a cellular appearance.

Classed with the *Cephalopoda* by some authors, but more properly with the *Foraminifera* by others, are many species of fossil chambered shells, known as *Nummulites*; they are all of a more or less flattened or disc-like shape, and consist of a series of minute chambers, separated from each other by septa, each having one or more apertures of communication, but without any siphonic tube running through them as in the *Nautilus* and *Spirula*; some of the species are nearly an inch in diameter, whilst others are of microscopic minuteness. The

intimate structure of Nummulites has been carefully investigated by Dr. Carpenter*, who finds that each successive whorl completely invests the one that preceded it, and that every chamber is connected with those both before and behind it by means of one or more tubular prolongations, and that every whorl is connected with the exterior by vertical passages. The structure of the shell itself is minutely tubular, being perforated in all directions; the tubes pass in a straight course from one surface of the shell to the other; their orifices are plainly shown in Plate XVI. fig. 24; according to Dr. Carpenter, their diameter is $\frac{1}{7500}$th of an inch; they run in parallel lines, and give to the walls of the chambers a striated appearance, as shown in fig. 23. All the margins of the whorls present a coarser tubular structure than the other parts of the shell, the tubes being arranged in a radiating manner; they are readily seen in Preparation A y 116.

A y 114. A horizontal section of a *Nummulite*, exhibiting five whorls and numerous septa, all being visible to the naked eye; when viewed with a power of 100 linear, the tubuli in the walls of the shell are shown very clearly; this specimen is represented in Plate XVII. fig. 1.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 115. A horizontal section of a *Nummulite*, *Nummulina lævigata*, from the London clay of Bracklesham; having one of its outer surfaces uppermost, it shows in a very remarkable manner the openings of the tubuli, the whole surface being covered with them. A portion of this preparation is represented in Plate XVI. fig. 24.

Presented by Dr. W. B. Carpenter, F.R.S.

A y 116. Two vertical sections of *Nummulina lævigata*, exhibiting the series of whorls of which each shell is composed, and clearly proving that every whorl is invested by the one succeeding it; the row of light spots in the median line are the chambers, and the dark vertical lines are the septa; one of these sections is represented in Plate XVI. fig. 22, under a power of 5 diameters, and a portion of the same more highly magnified in fig. 23; in this last the tubuli of the whorls are plainly shown.

Presented by Dr. W. B. Carpenter, F.R.S.

* Quarterly Journal of the Geological Society of London, vol. vi. Feb. 1850.

Subseries XII. *Structure of Pearls.*

In many species of Mollusca are found certain oval, or globular masses of nacreous material, known as *Pearls*; these are said to occur either in the mantle or ovarium of the animal, or firmly attached to some part of the internal surface of the shell. Pearls are most commonly found in oysters and mussels, and not unfrequently in the *Pinnæ*; they appear to be more abundant in shells from certain localities than from others, and the fisheries of the coast of Ceylon and of Olmutz in the Persian Gulf, are said to produce the finest specimens. The most valuable pearls are obtained from a large oyster, known as *Avicula margaritifera*, or from a mussel termed *Mya margaritifera*; they are also commonly found in the mussels of many rivers, both in Great Britain and Ireland, and in the latter country pearl fisheries existed nearly two centuries ago; but the British pearls are not so highly prized as those from the east. Pearls are not exclusively confined to particular species of Oysters or Mussels, but in some localities are as abundant in the commoner kinds as in the rarer species of these animals: the quality of the pearl depends upon its size, roundness and brilliancy, but it is only in those shells having a true nacreous layer that the finest specimens can be obtained; those occurring in the ordinary edible oysters and mussels are always more or less dull in appearance, in consequence of the internal layer of their shells being of the subnacreous variety, and their pearls, as will presently be shown, not unfrequently composed of prismatic cellular structure instead of *nacre*. Various opinions have long been entertained as to the mode in which pearls are formed; the general supposition is that they are developed upon a nucleus composed either of a blighted ovum, or of a foreign body; by some it is considered that the pearl is the result of disease; and by others that the animal, being cognizant of the attacks of the Whelk or other boring Gasteropod, immediately sets to work and secretes the pearly mass to stop the hole; this latter conclusion would only apply to such pearls as are attached to the shell. It will be shown, however, in the following series of preparations, that pearls almost invariably are developed upon a nucleus, and that in the prismatic or non-nacreous variety, the nucleus generally consists of a portion of brown horny matter, like that found on the edges of the shell either of a mussel or oyster,

this being the material in which the formation of new layers of shell are taking place ; in no case yet examined, has a nucleus consisting of an ovum been found ; one specimen, viz. A z 12, will prove that in the brown horny layer the pearls exhibiting the prismatic cellular structure are formed, whilst those truly nacreous have their origin in the body of the animal or in the nacre itself. Pearls, as shown by Preparation A z 14, may be produced artificially.

a. *Pearls exhibiting a prismatic cellular structure.*

A z 1. A transverse section of a round Pearl, probably from an Oyster, in the centre of which may be seen a brown horny nucleus, like that of the *periostracum* found on the edge of the shell; this is surrounded by a circle of small imperfectly formed prismatic cells: outside this is a thin ring of horny matter, then several other rows of larger prisms, and then a thin ring of horn, and lastly, between this and the margin are ten rows of still larger prisms. A segment of this section is represented in Plate XVIII. fig. 1, and a portion of the same more highly magnified in fig. 2 ; in this last, the striated condition of the prisms is well shown. In one of the large rings of horny matter a small pearl may be seen in progress of development.

A z 2. A horizontal section of another *Pearl* of irregular figure, having a central nucleus of horny matter surrounded by a band of cellular structure, in which the ends of prisms are divided transversely ; the prisms are smallest near the centre, and gradually increase in size towards the margin of the section ; all the cells near the centre are also nearly filled up with black matter, and the commencement of the same deposit may be observed in most of those near the margin ; in certain spots this is indicated by a projection inwards from the margin of the cell, of small angular bodies like crystals. In other parts may be seen the mode in which small cells are converted into larger ones by the absorption of the cell-walls. A portion of the margin of this specimen is represented in Plate XVIII. fig. 3 ; in the upper part may be seen many of the large cells exhibiting well-marked transverse striæ on their walls, and at the lower part other cells having a deposit of black matter in their interior.

A z 3. A horizontal section of a round *Pearl*, having a nucleus of horny material ;

surrounding this is a structure originally composed of prisms, but in which the cell-walls are now in process of becoming absorbed or destroyed. A segment of this section is represented in Plate XVIII. fig. 4, or more highly magnified in fig. 5.

A z 4. A horizontal section of a round *Pearl*, composed entirely of prismatic cellular structure, without any basis or nucleus of horny material; the prisms in the centre are divided transversely; their shape is somewhat longer than usual, and it would appear from the representation of this portion of the specimen in Plate XVIII. fig. 8, that the cell-walls were being absorbed, and that one large prism was formed of two or more small ones. In all the surrounding parts the prisms are cut more or less obliquely, so that their length and transverse diameter can be well seen.

b. *Pearls in which all trace of prismatic structure has disappeared.*

A z 5. A horizontal section of a small round *Pearl* from a Mussel; it consists of a series of concentric laminæ of a beautiful purple colour, in which no other structure can be seen than a series of fine curved or radiating lines. A segment of this section is represented in Plate XVIII. fig. 12.

A z 6. A horizontal section of another purple *Pearl* from a Mussel, consisting of a series of concentric zones, those in the centre being the richest in colour: no trace of prismatic cellular structure is visible in this preparation.

A z 7. A horizontal section of a dull yellow *Pearl* from an Oyster; it consists of a series of zones, in none of which the prismatic cellular structure can be seen.

A z 8. A horizontal section of a *Pearl*, in which the structure is so irregular, that neither a trace of prismatic cellular structure or of concentric zones can be seen. A portion of this preparation is represented in Plate XVIII. fig. 9.

c. *Pearls composed entirely of nacre (True pearls).*

A z 9. A horizontal section of a small Oriental *Pearl*, composed entirely of true nacre, which exhibits the beautiful colours characteristic of that structure.

A portion of this specimen is represented in Plate XVIII. fig. 6, under a power of 500 diameters, in order to show the lines by which the colours are produced. *Presented by Mr. J. T. Norman.*

d. *Pearls composed of nacre and prismatic cellular structure.*

A z 10. A horizontal section of a *Pearl*, exhibiting a central portion about $\frac{1}{6}$th of an inch in diameter, composed entirely of prismatic cellular structure; around this is a strong band of true *nacre*; this again is invested in parts by another layer of prismatic cellular tissue. A portion of this preparation is represented in Plate XVIII. fig. 7.

A z 11. A horizontal section of a true *Pearl*, having a very small centre composed of true nacre, around which is a band of prismatic cellular structure about $\frac{1}{30}$th of an inch in breadth; the remaining portion, $\frac{1}{8}$th of an inch broad, is composed of nacre.

e. *Development of pearls.*

A z 12. A transverse section of a portion of a *Pearl*, composed of prismatic cellular structure and horny material; in the latter, which will be found on the flattened edge, may be seen upwards of eight pearls in various stages of development. The brown horny material is identical with the periostracum on the edge of the lip of the shell, and in this tissue no doubt all the prismatic cellular pearls are developed.

A z 13. A transverse section of a small oriental *Pearl*, exhibiting a large opaque central nucleus with laminæ of nacre surrounding it; the nature of the nucleus cannot clearly be made out.

A z 14. A segment of a transverse section of a *Pearl*, from a species of Mussel, in which no less than five pearls, each of the size of a pea, were produced artificially by the introduction of a corresponding number of pieces of silver wire of the shape of an anchor. The segment exhibits all the characters of a genuine oriental pearl. The wires were introduced by the Chinese, and in the Pearl from which the section was taken, the part forming the nucleus is readily seen.

APPENDIX.

A. Page 10.

Hair-like bodies, similar to those found in the air-cavities of the petiole of *Nuphar lutea*, occur in other aquatic plants; in all cases they appear to be either the remains of cells which at one period of growth formed the septa between two air-cells, or septa in a rudimentary condition.

B. Page 11.

The markings seen around the hilum of the starch-grain, are said to indicate the successive stages of growth, and are considered not to be on the outer surface or cell-wall, but either on an inner membrane or in the granular contents. In certain plants, as the *Vallisneria*, the starch-grains may be seen in *situ*; and it may be observed that they are increased in number in one of two ways, either by the pullulation or fission of a parent grain, or by the development of three or four small grains in its interior.

C. Page 16.

The gland-like bodies found in the leaves of *Ficus elastica*, are considered by Meyen to be concretions of gum; in the specimen represented in Plate V. fig. 7, the pedicle did not reach the under surface of the cuticle, but in the generality of instances it does; the minute crystals would appear not to be composed either of the oxalate or phosphate of lime as the ordinary forms of raphides, but more probably of the carbonate, as they dissolve with effervescence when treated with very weak acids. Similar bodies are to be met with in the leaves of the Hop.

F 22 *a*. A portion of the upper surface of the leaf of *Ficus elastica*, exhibiting very plainly the gland-like bodies; each specimen is covered with a

delicate hexagonal cuticle, and the pedicle may be seen at some little distance below it. Some of the crystals are still present: they project from the outer surface of the globular mass.

D. Page 231.

Many foreign species of *Holothuria*, especially those known as *H. papillosa* and *tremula*, are remarkable for the number of their feet, each of which has a calcareous disc on its free extremity; and one species in particular, *H. squamata*, is provided on its upper surface with a convex calcareous coating, the under surface being flat and soft. The following specimens will afford good examples of the calcareous element of the cuticular skeleton, so characteristic of all the Echinodermata.

A t 8 *a*. Six calcareous discs, obtained from the extremities of the feet of a *Holothuria*, *H. papillosa*; each consists of a reticulated structure, like that shown in Plate XIV. fig. 12; and around the margin, as represented at *a*, there is an incomplete network, some parts of which, as shown in fig. 6, very much resemble the spicula of certain zoophytes.

A t 8 *b*. Five discs from the same *Holothuria*, which have been mounted in Canada balsam; they exhibit the characteristic structure more plainly than those of the preceding specimen; and one in particular very much resembles a transverse section of the spine of an Echinus.

Bodies similar in structure to these, but of much larger size, are to be found at the extremities of the ambulacral appendages of most of the *Echini*; they have been minutely described by Prof. Valentin in his monograph on the Echinodermata.

A t 8 *c*. A calcareous disc taken from the free extremity of one of the ambulacral appendages of an undescribed species of *Echinus*; it consists of five segments of calcareous matter, each exhibiting a structure very like that of the shell of the same animal, and the entire disc resembles a transverse section of one of the large spines.

A t 8 *d*. A portion of the calcareous integument of *Holothuria squamosa*, con-

sisting of small angular plates exhibiting the characteristic reticulated structure; amongst them may be seen others that are of a globular figure, and appear as if they were the representatives of the spines.

E. Page 232.

This preparation to illustrate the structure of an extinct species of Pentacrinite, has been made since the description of Preparation A t 11 was written.

A t 11 *a*. A transverse section of the stem of a fossil *Pentacrinite*, having a small opaque spot in its centre, from which five oval arms radiate; each one of these, as in the recent specimen, has a more or less serrated margin. A segment of the entire section is represented in Plate XV. fig. 3, under a magnifying power of 18 diameters, and the entire section itself at *a*. A portion of the margin, magnified 200 diameters, is shown at *b*, and serves to display the characteristic reticulated structure. In the segment represented in fig. 3, a row of small white spots like holes may be seen on the inner margin of the arms; they are also present in the segment of the recent specimen, shown in fig. 1.

F. Page 244.

Since the description of the structure of the spines of the Echinodermata, commencing at page 232, was written, several other specimens of so much interest have been prepared as to require mention here; amongst them are included some particularly worthy of notice, as showing the fact that spines when broken may to a certain extent be repaired.

A t 50 *a*. Spines obtained from a species of *Ophiura*; they are about $\frac{1}{6}$th of an inch in length, very brittle, and provided with serrated edges; all the upper parts of each specimen exhibit the characteristic reticulated structure, but a more dense tissue is found at the base: in this particular the base of the spine resembles that of an *Echinus* or a *Cidaris*.

A t 50 *b*. Spines obtained from a small undescribed species of *Spatangus*, which are on an average $\frac{1}{8}$th of an inch in length, and perfectly white; they exhibit precisely the same characters as the smallest spines of the *Echini*.

The specimen from which the spines were taken was of an oval figure, about two inches in the long, by one and a half in the short diameter, and not more than one-fourth of an inch in thickness.

Presented by Capt. Sir E. Home, Bart., R.N.

A t 50 *c*. A small British species of Echinoderm, *Echinocyamus pusillus*, which, according to Prof. Forbes, is one of the connecting links between the true *Echini* and the *Spatangaceæ*; its under surface is covered with exceedingly delicate white spines, which exhibit the characteristic reticulated structure, when viewed as opaque objects.

Presented by James McBain, Esq., M.D.

A t 50 *d*. A vertical section of the upper half of a spine of a large *Echinus*, probably *E. trigonarius*, which has been broken, and about half an inch of new matter added to the fractured extremity: this may be known by its dark colour and conical figure.

A t 50 *e*. A vertical section of the upper extremity of another spine of the same *Echinus*, which has been reduced sufficiently thin to be transparent; with the naked eye the line of demarcation between the new and the old material, as shown in Plate XV. fig. 18 *d*, may be readily seen; when this section is viewed with a power of 50 diameters, the pillars represented at *a* are very visible in the old part of the spine; but in the new, as shown at *b*, there are no pillars, and the line of fracture is very evident at *c c*: in addition to these differences in structure, the old part is of a more or less green colour, and the new of a reddish pink.

A t 50 *f*. A transverse section of a spine of a species of *Cidaris*, which has been treated with acid in order to remove all the calcareous matter. This specimen clearly shows that the radii of the outer margin or crust which have been described as tubes, are elongated cells connected with others forming the radii of the framework of the centre of the spine. They are particularly evident on one portion of the margin of the specimen, and from not being supported by the calcareous material, can be moved about very readily in the fluid in which the section is mounted.

G. Page 258.

In addition to the several points of interest exhibited by Preparation A v 22, may be mentioned the following important fact which has been observed on a very careful examination of the upper surface of the specimen, viz. that the cells of the cuticle, like those of the hard tissues of vegetables, have their walls in many places so thickened as to leave a dark central spot with radii projecting from its margin like the canaliculi of a bone-cell. A faint indication of this structure is given in Plate XV. fig. 8.

H. Page 269.

A y 13 *a*. A thin portion of a shell of *Terebratula Australis*, exhibiting three distinct laminæ, each presenting a different structure; the one here to be described is situated in the centre, and shows very plainly that this layer is composed of flattened bands or cells, which are capable of being separated from each other, and in certain parts are curved so as to form the walls of the perforations. The most characteristic portion of this specimen is represented in Plate XVII. fig. 17.

END OF VOL. I.

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EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Typical cells. *a.* Cells obtained from a ripe Strawberry, showing nuclei and nucleoli. *b.* Cells from the same plant altered by pressure. *c.* Nucleated cells, constituting the plant known as the Yeast Plant, *Torula cerevisiæ*. *d.* Vertical section of the leaf of *Lilium candidum*, exhibiting the lobed form of cellular tissue at *e*.

Fig. 2. Sections of the stem of an *Equisetum*. *a.* Transverse section, showing the more or less hexagonal shape of the cells. *b.* Vertical section of the same, exhibiting the elongated condition of the cells.

Fig. 3. Cells thickened by secondary deposit. *a.* Two elongated cells from the Garden Balsam, *Balsamina hortensis*, in which the secondary deposit has assumed a spiral form. *b.* Two cells from the Elder, *Sambucus nigra*, in which the deposit has been carried to a greater extent, and the cell-wall is entirely covered with it, except in those parts where minute oval dots are shown. This form of cell is known as the dotted or porous cell. *c.* An old ligneous cell from Snakewood, whose cavity is nearly filled up by a deposit of woody matter. *d.* Cells constituting the gritty tissue of the Pear, *Pyrus malus*, showing an extensive secondary deposit filling all parts of the cell except those indicated by dark lines, which are canals communicating with the central cavities.

Fig. 4. Cells obtained by maceration from the leaf of *Pleurothallis ruscifolia*, having a large spiral fibre wound round their interior; hence they have been termed fibro-cellular tissue. When the cell-wall is ruptured, the fibre, as shown at *a*, will readily unroll.

Fig. 5. Cells obtained by maceration from Rhubarb, *Rheum palmatum*. *a.* Filled with starch. *b.* A large oval cell enclosing a stellate bundle of raphides of oxalate of lime.

Fig. 6. Deposit in the interior of cells. *a.* A portion of the leaf of a *Sphagnum* with a spiral fibre in the interior of the cells. *b.* Cells from a fossil Palm from Antigua, exhibiting a deposit of secondary matter in concentric strata. *c.* Portion of the cuticle of *Aloe verrucosa*, showing a deposit on the outer surface of a cell.

Fig. 7. Cells with lacunæ. *a.* Two cells of a septum of an air-cell from the petiole of *Sparganium ramosum*, with triangular openings or lacunæ on their margins. *b.* A larger portion of the septum from a younger petiole, exhibiting a greater number of lacunæ of very small size.

Fig. 8. Woody tissue. *a.* An elongated tube or cell pointed at both ends, from the stem of *Canna bicolor*. *b.* A bundle of the same cells arranged side by side. *c.* A portion of woody fibre of an *Araucaria*, whose walls present a dotted appearance. *d.* A bundle of the same fibres. *e.* Spiral fibres from the elater of *Jungermannia*.

Fig. 9. Porous cells, *a.* obtained from the testa of the seed of a Gourd, which communicate with each other, and much resemble branching ducts. *b.* Cells cast off from the testa of the seed of a *Salvia*, which consist of a delicate, structureless membrane enclosing a spiral fibre.

Fig. 10. A transverse section of Yew, *Taxus baccata*, *a.* showing woody tubes with thickened walls. *b.* A vertical section of *Drimys Winteri*, consisting of three woody fibres, with two or more rows of pores in each.

Fig. 11. Glandular woody tissue. *a.* A fossil fibre of coniferous wood from Fredericsburg, Virginia, exhibiting a spiral arrangement of very delicate fibres in its interior, and on its outer surface a row of bordered pores. *b.* The casts of the pores detached from the woody fibres. *c.* The casts projecting from the outer surface of the fibre. *d, e.* Woody fibres from *Aporum anceps*, with projecting cells. *f.* A portion of the same, from which the cells *g* have been detached.

Fig. 12. A vertical section of Yew, *Taxus baccata*, exhibiting bordered pores, co-existing with spiral fibres.

HISTOLOGY OF VEGETABLES.

Fig. 1. 400 dias

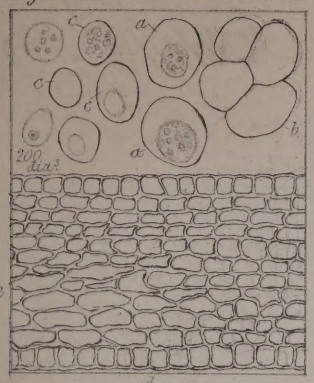


Fig. 2. 100 dias

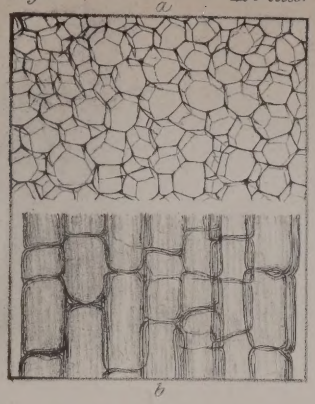


Fig. 3. 100 dias

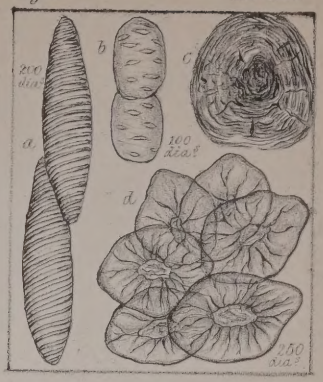
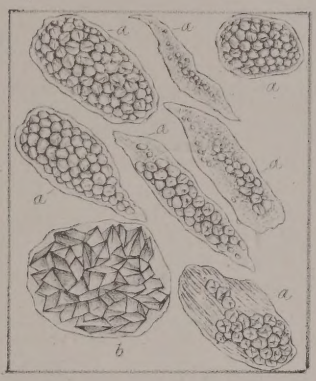


Fig. 4. 250 dias

Fig. 5. 250 dias



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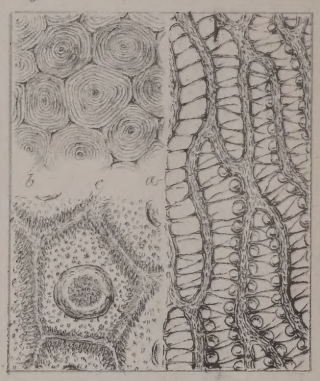

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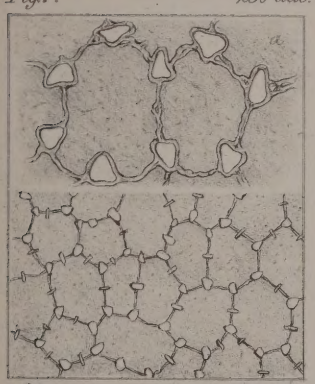
Fig. 7. 250 dias



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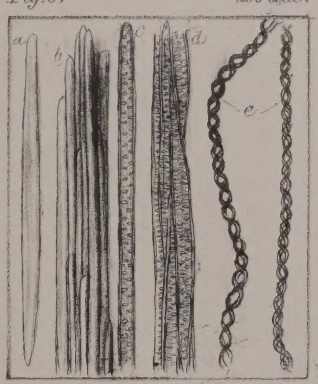

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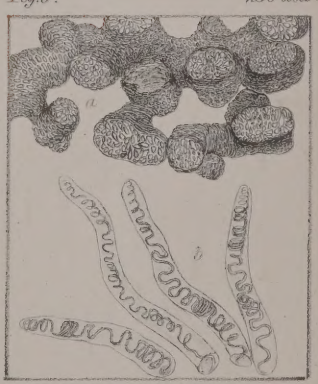

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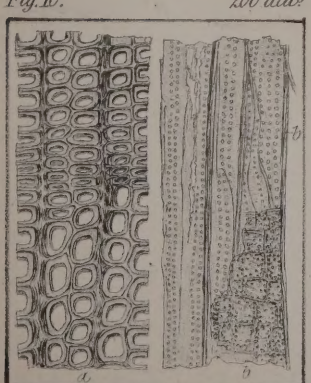

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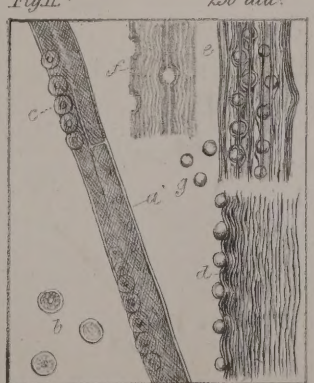
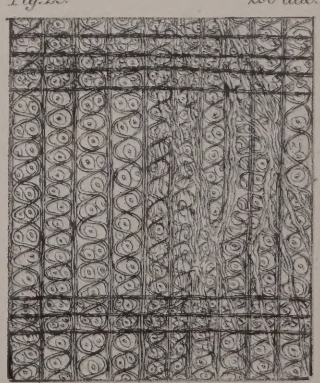


Fig. 12. 200 dias



Lens Aldous, Xinc.

Day & Son, lith.rs to the Queen.

PLATE II.

Fig. 1. Starch-granules. *a*. Small angular granules from a grain of Rice. *b*. Larger granules from a Potato, showing the central spot or *hilum*. *c*. Granules from the *Tous les mois*, with a double *hilum* in the two largest specimens.

Fig. 2. A portion of one of the outer layers of the bulb of a Squill, *Scilla maritima*, exhibiting a great abundance of acicular raphides; some of them still remain in the cells, but many of the larger specimens lie loose upon the membrane.

Fig. 3. Raphides from the root of the Rhubarb, *Rheum palmatum*. *a*. Stellate or conglomerate crystals of oxalate of lime. *b*. Smaller detached crystals.

Fig. 4. Raphides from the outer layer of the bulb of a small Onion. *a*. Cells containing prismatic and octohedral crystals of oxalate of lime. *b*. Cells containing masses of prisms arranged in a stellate form, together with large octohedral crystals.

Fig. 5. Raphides from the bark of the Lime, *Tilia Europæa*. *a*. Stellate and rhombohedral crystals of oxalate of lime. *b*. Flattened crystals pointed at both ends; their general direction is in parallel rows, with their apices nearly touching each other. *c*. The same crystals *in situ* in the cells of the bark. *d*. A portion of the stalk of *Elæagnus angustifolia*, exhibiting large prismatic raphides in its cells.

Fig. 6. Raphides of a peculiar figure from the bark of the Apple. *a*. Crystals seen both in their natural situation and separated from the tissue. *b*. A portion of the testa of the seed of the Elm, the cells of which contain small prismatic raphides.

Fig. 7. Scalariform vessels. *a*. A vertical section of the root of a Fern, *Diplazium Seramporense*, exhibiting three scalariform vessels; these, when cut transversely, are found to be of an octangular figure. *b*. An annular vessel with short thick rings, from the *Equisetum fluviatile*.

Fig. 8. Porous cells. *a*. A portion of one of the elongated cells from the wing of the seed of *Lophospermum erubescens*, in which the deposit is more or less spiral and reticulated. *b*, *c*, *d*. Portions of three elongated cells forming the roots of *Marchantia polymorpha*, in one of which, *c*, the deposit has just commenced and small triangular pores are left, whilst in *b* and *d* it has gone so far as to assume a more or less spiral arrangement.

Fig. 9. Porous cells. *a*. A porous cell from the testa of the seed of the Almond, *Amygdalus dulcis*. *b*. A portion of a large vessel from a vertical section of the stem of *Piper nigrum*, in which are seen both pores and slits; some of the pores have a fibre passing through their long diameter; the torn edge of the vessel shows the ends of the fibres deposited within its membranous wall. *c*. A portion of a vessel from the Elm, *Ulmus campestris*, in the upper part of which are shown large pores closely arranged, and in the lower the presence of small spiral fibres between the pores.

Fig. 10. Porous cells. *a*. A portion of a vertical section of the root of the Alder, *Alnus glutinosa*, exhibiting a duct in which the pores are remarkable for their large size. In the upper part of the duct, as at *a*, the walls are perfect, but at *b* the anterior wall has been removed to show the interior structure. *c* represents a portion of the duct more highly magnified. *d*. Cells in the neighbourhood of the duct, also porous.

Fig. 11. Porous cells. *a*. A portion of a large vessel from a Balsam, *Balsamina hortensis*, in which pores are produced by the thickening of the fibre and by vertical bands connecting the spirals together; in this specimen the membrane over the pores has been absorbed, and perforations result. *b*. A portion of a large vessel from a fossil wood, which is remarkable for the small size of its interior fibre and for the frequent bifurcation of the same. *c*. A portion of a vessel, originally porous, from a fossil wood, which presents a curiously reticulated structure.

Fig. 12. A portion of a vessel, *a*. from a fossil wood, which consists of vertical striæ with oval pores. *b*. A portion of the same vessel more highly magnified, showing the shape of the pores and a beaded structure in the vertical striæ; the membrane has been absorbed, and perforations result. *c*. A portion of a vessel from a fossil wood, in which the pores have concentric rings around them; in those places in which no rings are present, the pore has, as it were, dropped out. *d*. A portion of a vessel from the Elm, showing the coexistence of spiral fibres with large pores.

HISTOLOGY OF VEGETABLES.

Plate II.

Fig. 1. 250 diaˢ

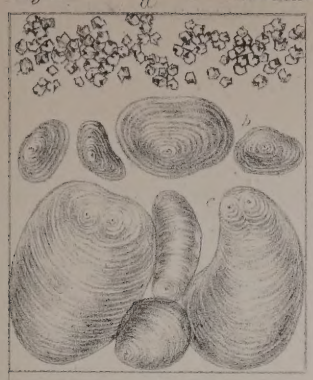
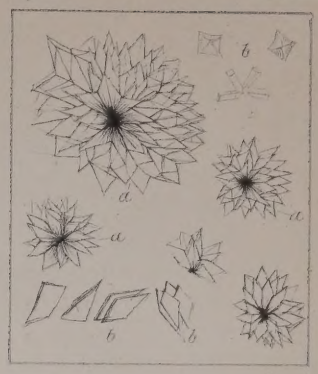


Fig. 2. 250 diaˢ

Fig. 3. 250 diaˢ



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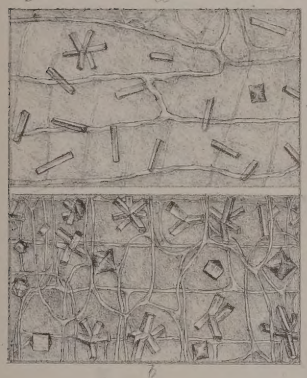

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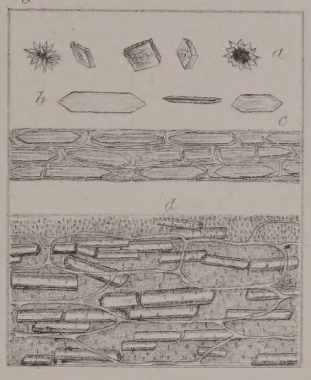

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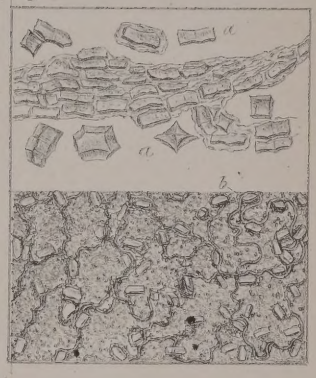

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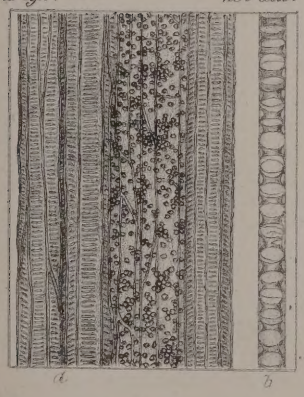
Fig. 7. 250 diaˢ



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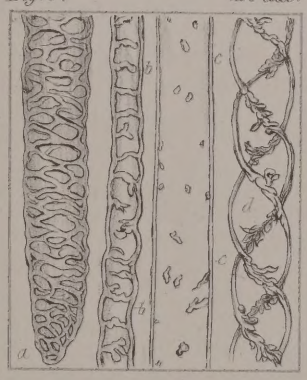

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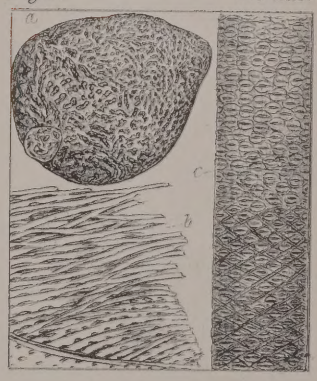

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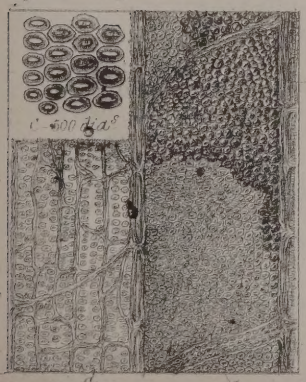

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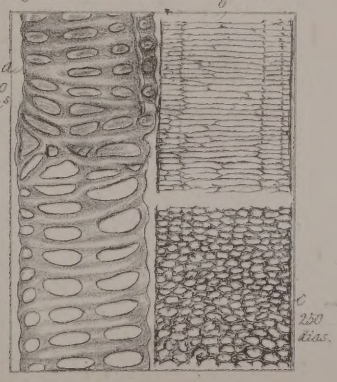

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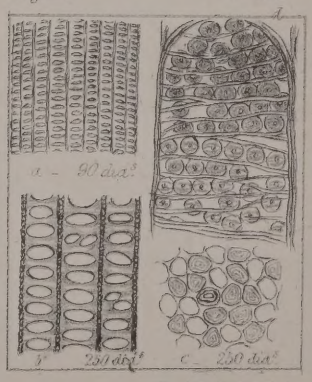


Lewis Aldous Zinc.

Dizy & Son, Lith.rs to the Queen.

PLATE III.

Fig. 1. A vertical section of the stalk of *Polygonum orientale*, exhibiting a spiral and a scalariform vessel; the former being bounded by elongated porous cells, the latter by a group of similar cells having two transverse bands, showing that in all probability this last assemblage of cells is in process of becoming one large vessel. *a*. Portions of two reticulated vessels from *Opuntia vulgaris*, one of which is unrolled.

Fig. 2. Stellate tissue from a transverse section of the stem of a Rush. *a a*. Dark lines indicating the divisions of the cells. *b b*. Triangular spaces termed *lacunæ*. *c*. A cell from a septum of an air-cavity of *Sparganium ramosum*, in process of becoming stellate by the enlargement of the lacunæ. *d*. A stellate hair-like body from an air-cell of *Nuphar lutea*.

Fig. 3. A vertical section of the stem of *Testudinaria Elephantipes*, exhibiting a large mass of simple porous ducts in the midst of large cells, which are also slightly porous.

Fig. 4. A vessel from *Canna bicolor*, having longitudinal and spiral fibres. *a*. A portion of the vessel in which the longitudinal are of smaller size than the spiral fibres. *b*. A portion of the same vessel unrolled, with the longitudinal fibres projecting beyond the edges of the spirals. *c*. A portion of a large vessel from the same plant, in which both sets of fibres are of equal size. *d*. Part of another vessel, in which both sets of fibres are of equal size and equidistant, so that its surface is marked out in minute squares.

Fig. 5. Spiral vessels. *a*. A small spiral vessel from the leaf of *Anagallis arvensis*, showing its pointed extremities. *b*. A branched spiral vessel from the Leek. *c*. A compound spiral vessel from the stem of *Hedychium Gardnerium*. *d*. Another portion of the same vessel: both these are unrolled, and from nine to twenty fibres constitute the band.

Fig. 6. Portions of a duct dissected from a Fern, *Asplenium pubescens*. *a*. One extremity exhibiting the scalariform type. *b*. The middle portion of the same vessel becoming spiral at its lower end, *c*. *d*. The opposite extremity of the same vessel, which is again scalariform, but capable of being unrolled, as at *e*.

Fig. 7. Sections of the Ivory Nut, *Phytelephas macrocarpa*. *a*. A vertical section showing large thick-walled cells and pores communicating with a central cavity; the pores have dilated extremities, which are situated opposite those of neighbouring cells, but never communicate with them, the cell-wall being always between them. *b*. A transverse section of the same Nut, showing the short diameter of the cavity of the cell and the pores radiating from it.

Fig. 8. Vessels obtained from *Opuntia vulgaris*, having the fibre so much thickened as to form flattened discs; some of these are connected together by a spiral band. The membranous wall of the vessels is well displayed at *a a a a*. *b b*. The discs detached from the vessel. *c*. Siliceous casts of the interior of spiral vessels.

Fig. 9. Spiral vessels. *a*. A bundle of four vessels, obtained from the root of a Lettuce, the one on the right being dotted, the other three with spiral fibres, in which the turns are more or less widely separated from each other; of these the one on the left is the oldest, the membranous wall having grown more rapidly than the spiral fibre. *b b*. Two portions of a vessel called scalariform, obtained from a Fern, *Asplenium pubescens*, which is capable of being unrolled like a compound spiral vessel.

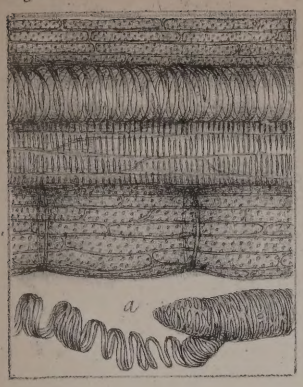
Fig. 10. Hard tissues. *a*. A transverse section of the seed of *Croton tiglium*, which consists of thick-walled cells of hexagonal figure, having a central cavity with radiating pores. *b*. A transverse section of the outer shell of the Ivory Nut, consisting of large cells with a great number of radiating pores.

Fig. 11. Hard tissues. *a*. A portion of the seed of the Star Anise, consisting of cells with radiating pores with small lateral branches; the *sclerogen* is deposited in concentric strata. *b*. A section of a Nut, *Corylus avellanus*, consisting of cells of irregular shape, with large cavities and small radiating pores.

Fig. 12. Hard tissues. *a*. Cells obtained from the cone of *Pinus Webbiana*, showing the size of the central cavity and the pores communicating with it. *b*. A transverse section of the same cone, showing the thickness of the sclerogen deposited in the walls of the cells.

HISTOLOGY OF VEGETABLES.

Fig.1. 250 dias



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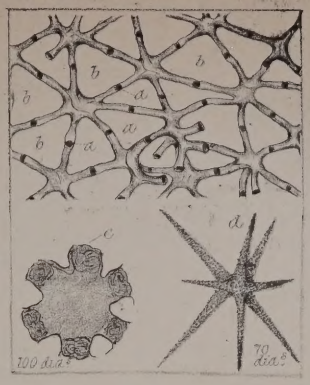


Fig.3. 200 dias

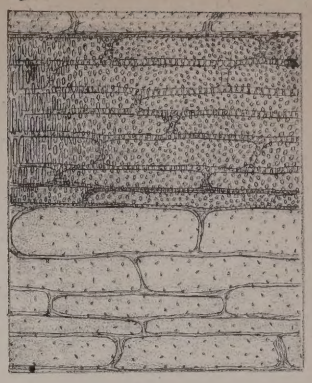
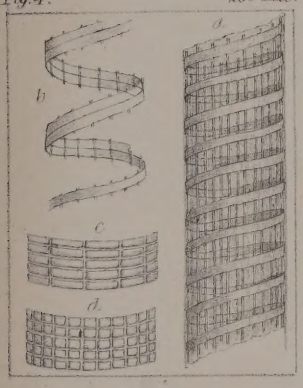


Fig.4. 250 dias



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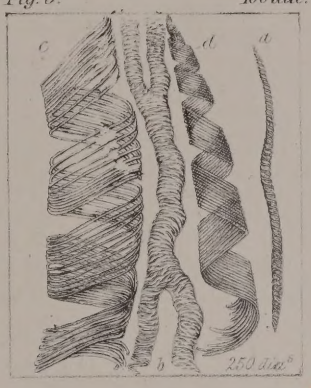

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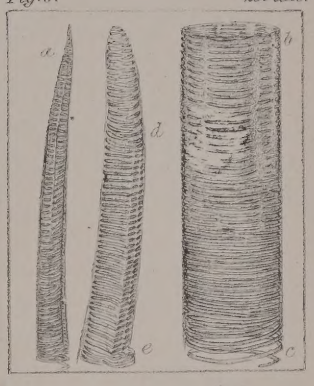

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Fig.7. 250 dias

Fig.8. 250 dias

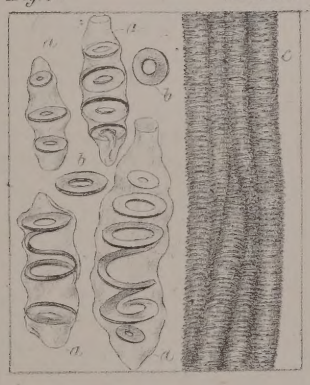
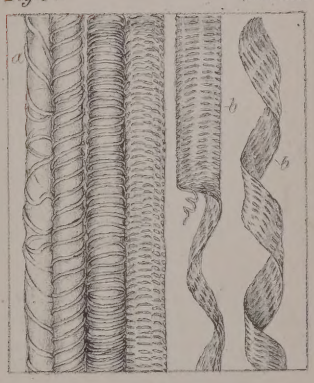


Fig.9. 250 dias



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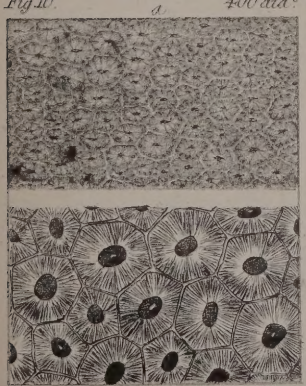
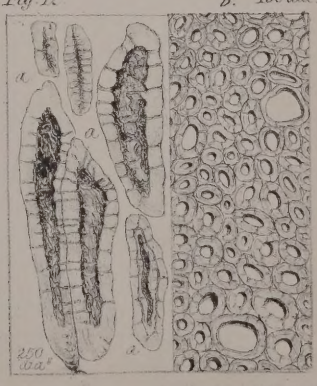


Fig.11. 250 dias

Fig.12. 150 dias



Lens Aldous, Zinc.

Day & Son, lith. to the Queen.

PLATE IV.

Fig. 1. Filamentous cells from a *Boletus*.

Fig. 2. Filamentous cells from a Mushroom, *Agaricus campestris*.

Fig. 3. Portions of two hairs from the testa of the seed of *Acanthodium spicatum*. *a*. The upper part of a hair, showing the spiral fibre within a membrane. *b*. A portion of another hair with a spiral fibre without membrane.

Fig. 4. A portion of a jointed hair of *Alstrœmeria ovata*, with delicate fibres within the membrane, which give the latter an appearance of being composed of fibres.

Fig. 5. Starch-granules from an Indian Bean, with peculiar slit-like markings and concentric striæ.

Fig. 6. Bodies of an amylaceous nature from the milky juice of *Euphorbia splendens*.

Fig. 7. A portion of a vertical section of a leaf of the India-rubber tree, *Ficus elastica*, exhibiting a large cell, in which is suspended a peculiar shaped body, supposed to be either a gland or an abortive hair, which in some cases is covered with crystals resembling conglomerate raphides.

Fig. 8. Two thick-walled cells with radiating pores from the petiole of *Hoya carnosa*.

Fig. 9. A portion of the wing of the seed of *Sphenogyne speciosa*, consisting of very delicate cells enclosing a spiral fibre.

Fig. 10. A portion of a vessel from a fossil Exogen, the walls of which are minutely porous.

Fig. 11. Portions of minute tubes from the base of the seed of *Sphenogyne speciosa*. *a*. A small tube enclosing a spiral fibre. *b*. A larger tube with its edges slightly beaded. *c*. A portion of the same tube more highly magnified, in which the beaded edges are better seen; this appearance being due to the sudden bending of the spiral fibre.

Fig. 12. An annular vessel from the flowering stem of the Leek, *Allium porrum*.

Fig. 13. A portion of a dotted vessel from Anthracite Coal.

Fig. 14. Portions of two vessels from a Stigmaria, in which, from the frequent branching of the fibre, a reticulated structure is presented; the fibres of one vessel also appear to pass across and join those of the neighbouring vessels.

Fig. 15. A portion of two reticulated vessels from a fossil Palm, showing the mode in which they terminate in pointed extremities, overlapping each other; coarse fibrous bands only are here seen, the membrane between them having been absorbed.

Fig. 16. A portion of a vessel from a fossil wood found at Herne Bay, Kent, with large pores, having a dark line or fibre passing through the centre of each. *a*. Three of the pores more highly magnified, showing the line to be double and in some cases to pass across two pores.

Fig. 17. Woody fibres of a fossil wood from Greenland, in which are spiral bands interlacing each other so as to leave triangular and slit-like spaces.

Fig. 18. Woody fibres of a fossil wood from Kennawha, Ohio, in which are three or more rows of pores.

Fig. 19. Sections of woody fibres of *Pinus Strobus*. *a*, *b*. The walls of two fibres. *c c*. The pores or glands divided through their long diameter. *d d*. The small central canals or pores communicating with the last.

Fig. 20. A woody fibre from *Pinus Strobus*, showing large bordered pores or glands.

Fig. 21. Woody fibres of the root of Elder with minute pores; the transverse lines on their walls indicate the depth of the pores.

Fig. 22. A portion of a scalariform vessel from *Diplazium seramporense* with beaded walls.

Fig. 23. Left-handed spiral vessels from a fossil Palm.

Fig. 24. A portion of the testa of the seed of *Acanthodium spicatum*, composed of thickened cells of peculiar figure.

Fig. 25. Woody fibres from *Salisburia adiantifolia*. *a*. A fibre with large pores, each with an oval marking in its centre. *b*. Another specimen in which the central markings of both sides of the fibre are seen together, and from being inclined at right angles to each other a crucial appearance is produced.

Fig. 26. A woody fibre of *Araucaria excelsa*, with bordered pores and spiral fibres.

Fig. 27. Woody fibres from *Cycas revoluta* with bordered pores, each having a slit-like marking in its centre; when both the upper and under surface of the fibre are in focus at the same time, a crucial appearance results. *a*. A fibre, in which are numerous slits, but only a few bordered pores. *b b*. The under surface of another fibre, showing pores with one slit-like marking. *c*. The upper surface of the same fibre, showing the direction of the slit to be at right angles to that of the pores in the opposite surface; when both are in focus together a cross results.

Fig. 28. Fructification of a Moss, *Polytrichum commune*. *a*. Two cells from an Antheridium, each containing a spiral filament. *b*. An Antheridium. *c*. A Paraphysis. *d*. An Antheridium ruptured, showing the escape of the cells. *e*. A spiral filament out of a cell.

Fig. 29. A portion of a vessel from a Fern, *Pteris aquilina*, showing that the oval markings are due to the deficiency of the deposit in those parts where they occur.

Fig. 30. An oblique section of a bundle of scalariform vessels from *Pteris aquilina*.

Fig. 31. Laticiferous vessels dissected from the stipule of *Ficus elastica*, showing that they have perfect walls and that they frequently branch.

Fig. 32. A portion of a woody fibre from a fossil coniferous wood, with delicate spirals in its interior.

Fig. 33. A portion of a woody fibre from Durham coal, in which are two spiral bands interlacing each other and leaving small angular spaces between them.

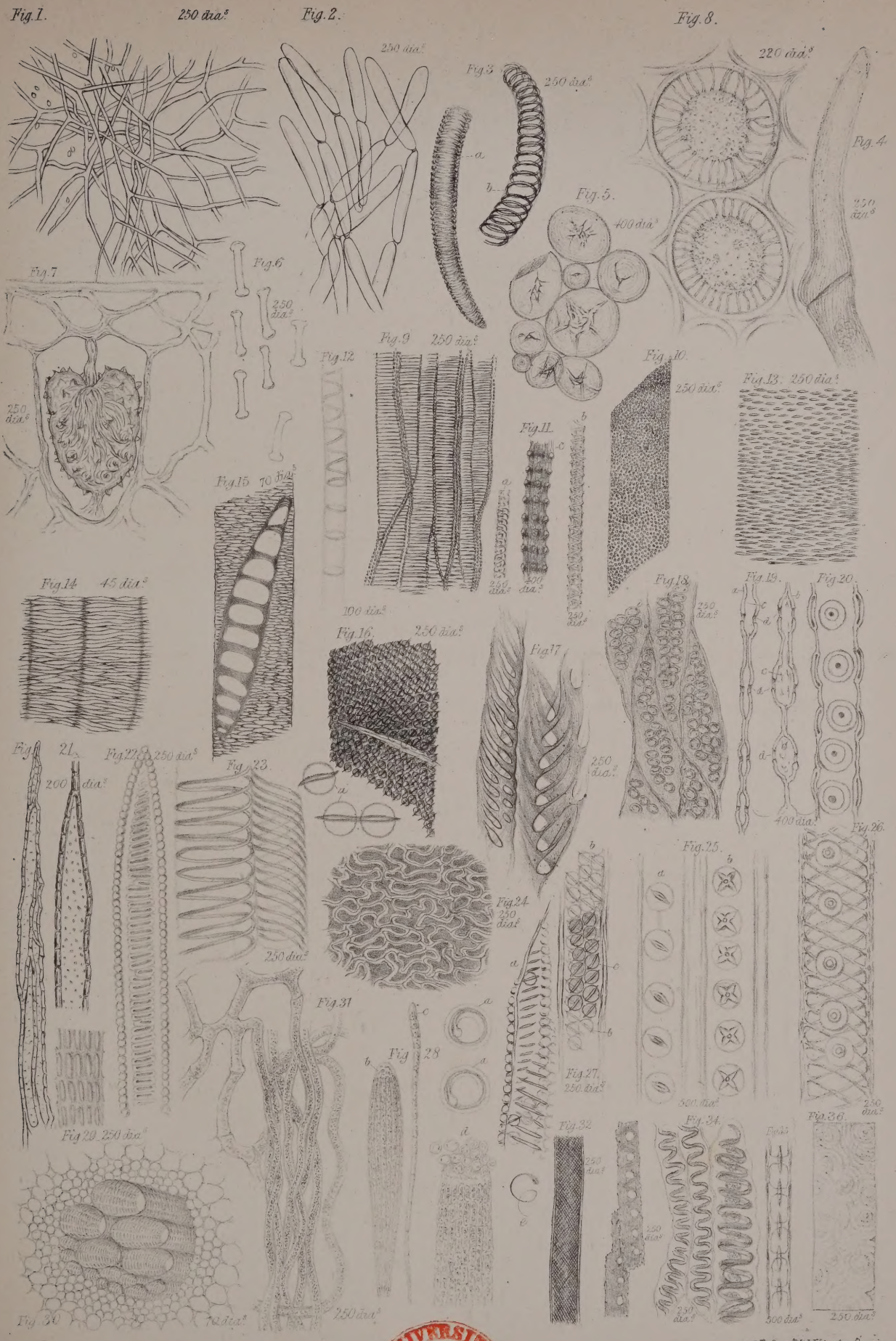
Fig. 34. Cells containing spiral fibres from *Equisetum arvense*.

Fig. 35. A row of pores between two woody fibres of *Salisburia adiantifolia* divided vertically, showing the shape of the cavities producing the peculiar slit-like markings.

Fig. 36. A fibre of silicified coniferous wood from Australia, showing the concentric rings of agate.

HISTOLOGY OF VEGETABLES.

Plate IV.



Lens Aldous, Zinc.

Day & Son, Lith.rs to the Queen

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PLATE V.

Fig. 1. Animal cells. *a.* A single adipose cell. *b.* Three adipose cells, their shape being altered by pressure. *c c.* Cells from the chorda dorsalis of the Lamprey, *Petromyzon marinus*. *d d.* Nuclei and nucleoli of the same cells.

Fig. 2. Membrane in the form of a sheath. *a, b.* Two fasciculi of the muscle of an Eel, *Anguilla acutirostris*, exhibiting a sheath of structureless membrane, termed sarcolemma. *c.* Two corpuscles of the blood of *Lepidosiren annectens*.

Fig. 3. Vessels in a portion of the posterior half of the capsule of the lens of the eye of a Kitten.

Fig. 4. A portion of the tendon of the rectus externus muscle of the eye of a Human subject.

Fig. 5. Vessels of white fibrous tissue. *a.* Vessels in the substance of the tendon. *b.* Vessels of the outer surface.

Fig. 6. Vessels of areolar tissue from the Pig.

Fig. 7. Areolar tissue. *a.* White fibres. *b.* Yellow fibres. *c, d, e.* Nucleated fibre forming cells seen in areolar tissue, after being acted on by acetic acid.

Fig. 8. Areolar tissue. *a, b, c.* Portions of areolar tissue from the base of the brain of a Sheep, acted on by acetic acid; the white element exhibits a tubular appearance, and is surrounded by bands of the yellow fibre. *d.* A portion of a fibrous tumour acted on by acetic acid, in which nucleated cells are well shown.

Fig. 9. A portion of the ligamentum nuchæ of a Sheep, which is composed of yellow fibrous or elastic tissue.

Fig. 10. Elastic tissue from the ligamentum nuchæ of a Giraffe. *a.* Fibres magnified 200 diameters. *b, c, d.* Portions of the same, magnified 400 diameters.

Fig. 11. Fibrous tissue from the membrane lining the interior of the shell of the egg of the common Fowl.

Fig. 12. Elastic tissue. *a.* A portion of the ligament of a shell, *Cyrena purpurea*. *b.* Vessels from the ligamentum nuchæ of a young Calf.

HISTOLOGY OF ANIMALS.

SIMPLE MEMBRANE AND FIBROUS TISSUE.

Plate V.

Fig. 1. 250 dias

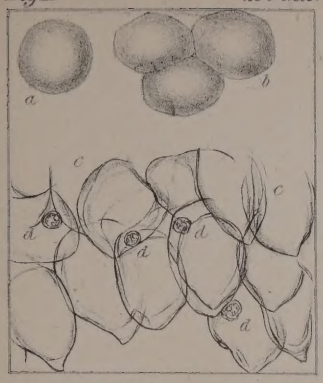

Fig. 2. 25 dias

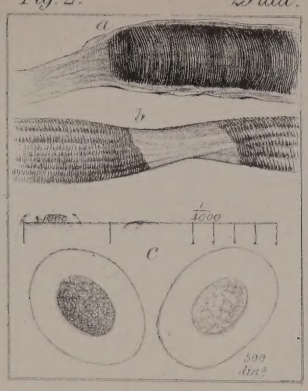

Fig. 3. 45 dias

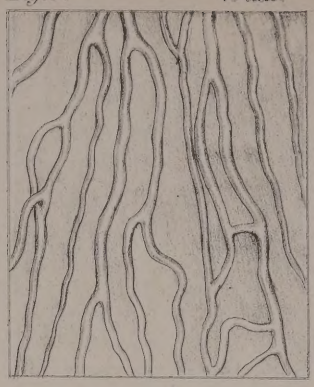

Fig. 4. 250 dias

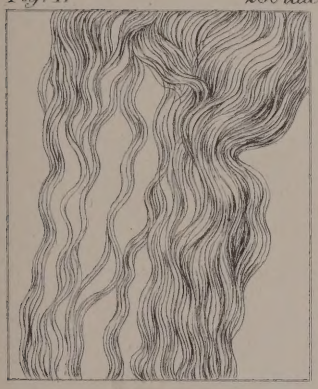

Fig. 5. 25 dias

Fig. 6. 50 dias

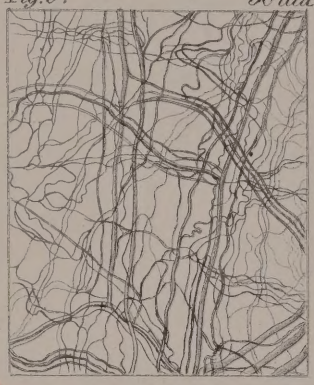

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Fig. 7 250 dias

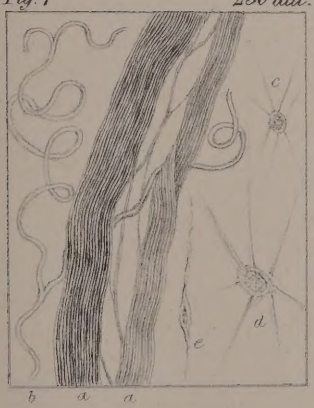


Fig. 8. 250 dias

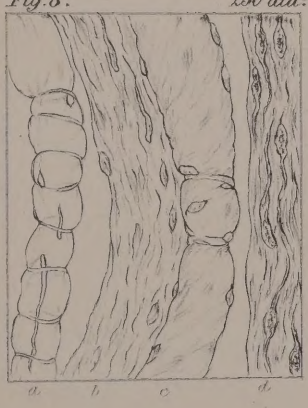


Fig. 9. 250 dias

Fig. 10. 250 dias

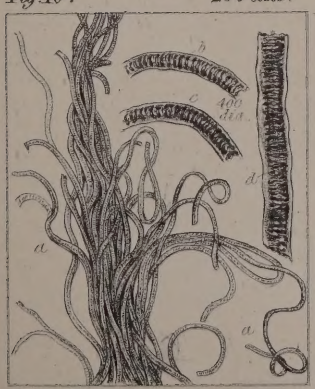


Fig. 11. 250 dias

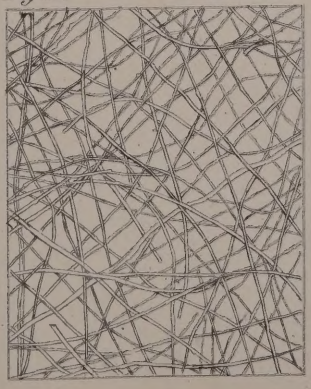
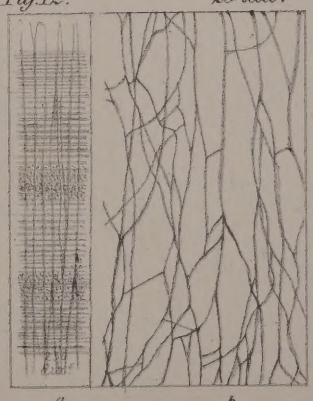


Fig. 12. 25 dias



Lens Aldous, Imp.

Day & Son, Lith.rs to the Queen

PLATE VI.

Fig. 1. Transverse section of cartilage from inner surface of the mantle of a Cuttle-fish, *Sepia officinalis*, showing nucleated cells of peculiar figure.

Fig. 2. Portions of two of the oral filaments of a Lancelet, *Branchiostoma lanceolatus*, exhibiting a structure more nearly allied to cartilage than to any other tissue.

Fig. 3. A portion of the *chorda dorsalis* of a Lampern, *Petromyzon fluviatilis*, consisting of a mass of large nucleated cells of cartilage.

Fig. 4. A vertical section of cartilage from the cranium of a Sturgeon, *Acipenser Sturio*, exhibiting numerous nucleated cells of a nodulated figure.

Fig. 5. A vertical section of the cranial cartilage of a Skate, *Raia Batis*, exhibiting nucleated cells arranged in clusters of three or more in a cluster.

Fig. 6. A vertical section of the cranial cartilage of a Lepidosiren, *Lepidosiren annectens*, exhibiting cells in which the nuclei are of large size.

Fig. 7. A vertical section of the cranial cartilage of a Siren, *Siren lacertina*, exhibiting very large cells with nuclei of proportionate size.

Fig. 8. A portion of the *chorda dorsalis* of the tadpole of a Toad, composed of large hexagonal cells exhibiting no trace of nuclei.

Fig. 9. A vertical section of the cranial cartilage of the tadpole of a Toad, *Bufo vulgaris*, consisting of a mass of large nucleated cells closely packed together.

Fig. 10. A vertical section of the cranial cartilage of the tadpole of a Frog, *Rana paradoxa*, consisting of a layer of nucleated cells of a more or less square figure.

Fig. 11. A vertical section of cartilage from the sternum of a Frog, composed of a layer of elongated oval cells exhibiting both nuclei and nucleoli.

Fig. 12. A longitudinal section of the cartilage from the rib of a Crocodile, *Crocodilus acutus*, composed of a series of small cells of peculiar figure, arranged in rows of three or four: all have granular nuclei.

HISTOLOGY OF ANIMALS,

CARTILAGE.

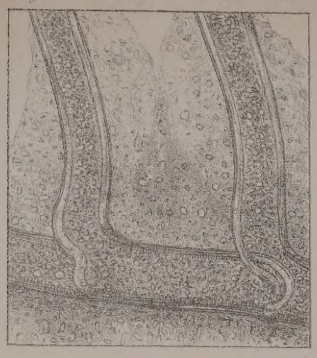
Plate VI

Cuttle Fish.

Fig. 1. 200 dia.s

Lancelet.

Fig. 2. 180 dia.s

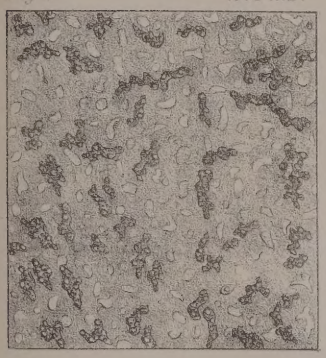


Lampern.

Fig. 3. (Chorda dorsalis.) 200 dia.s

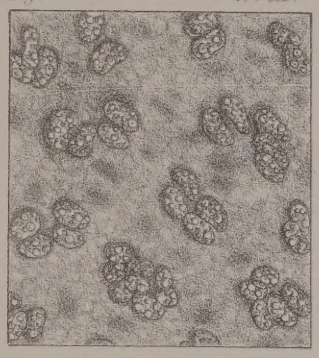
Sturgeon.

Fig. 4. 200 dia.s



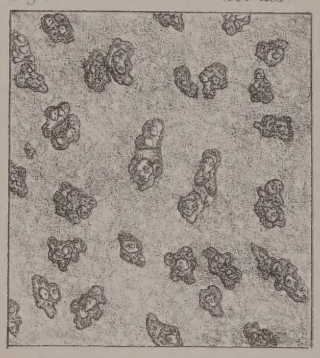
Skate.

Fig. 5. 200 dia.s



Lepidosiren.

Fig. 6. 200 dia



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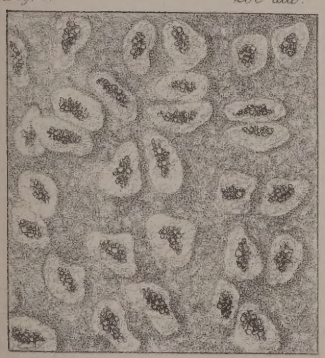
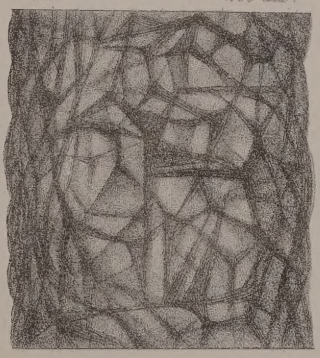
Siren

Fig. 7. 200 dia.s



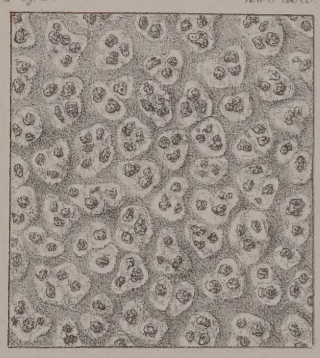
Tadpole of Toad.

Fig. 8. (Chorda dorsalis.) 200 dia.s



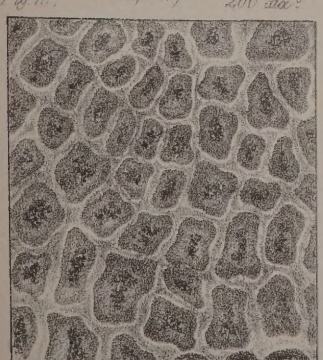
Tadpole of Toad.

Fig. 9. 200 dia.s



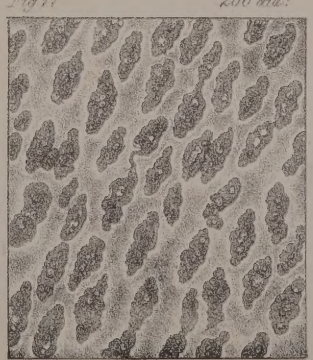
Rana paradoxa.

Fig. 10. (Tadpole.) 200 dia.s



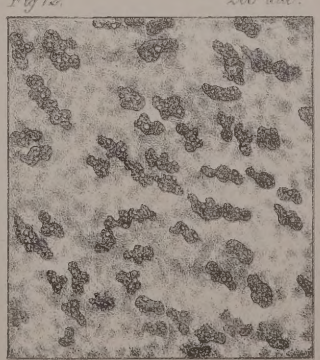
Frog.

Fig. 11. 200 dia.s



Crocodile.

Fig. 12. 200 dia.s



J. W. Leonard del. et lith.

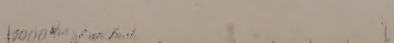


PLATE VII.

Fig. 1. Cartilage of the Albatros, *Diomedea exulans*. *a*. Vertical section exhibiting numerous cells of very small size. *b*. A horizontal section of the same, exhibiting larger cells with both cell-wall and nucleus.

Fig. 2. A portion of the cartilage of the ear of a Long-eared Bat, *Plecotus auritus*, consisting of equal-sized hexagonal nucleated cells, arranged in a single layer.

Fig. 3. Cartilage from the ear of a Bat, *Vespertilio pipistrellus*, consisting of a series of hexagonal cells, arranged in layers one over the other.

Fig. 4. Cartilage from the ear of a White Mouse, exhibiting several superimposed layers; the entire specimen resembles a section of vegetable cellular tissue.

Fig. 5. A transverse section of the cartilage of the ear of a Rabbit, exhibiting large cells loosely imbedded in a fibrous matrix.

Fig. 6. A longitudinal section of thyroid cartilage of a Whale, *Balæna Boops*, exhibiting elongated or fusiform cells.

Fig. 7. A vertical section of cartilage of an Elephant, *Elephas Indicus*, exhibiting cells of very large size, made up of a number of smaller ones.

Fig. 8. A horizontal section of costal cartilage of the Human subject, exhibiting large cells arranged in groups; each cell has a granular nucleus.

Fig. 9. A transverse section of articular cartilage from the distal extremity of the first phalanx of the great toe of a Human subject, exhibiting the coalescence of several small cells to form a large one.

Fig. 10. Vertical section of a cartilaginous tumour, called *Enchondroma*, consisting of a series of large nucleated cells imbedded in a fibrous intercellular substance.

Fig. 11. Vertical section of an Enchondromatous tumour from one of the joints of the fingers, exhibiting numerous branched cells, like those in the cartilage of the Cuttle-fish in Plate VI. fig. 1.

Fig. 12. Vertical section of an Enchondromatous tumour of the testicle, exhibiting cells containing a central nucleus of bony matter.

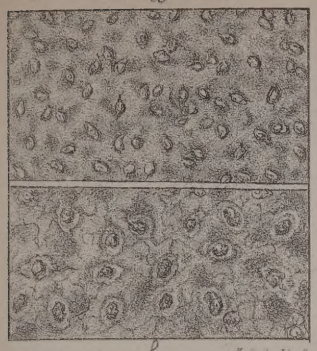
HISTOLOGY OF ANIMALS,

CARTILAGE.

Plate. VII.

Albatross.

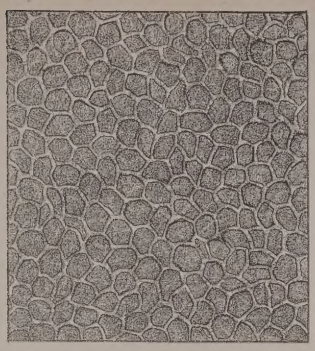
Fig. 1. 200 dia.s



500 dia.s

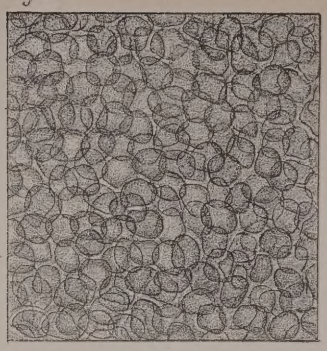
Bat.

Fig 2. 200 dia.s



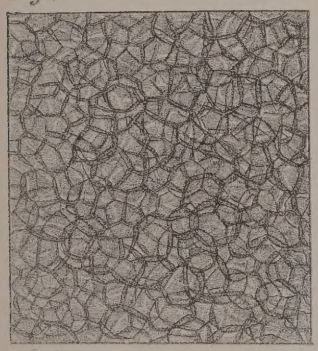
Bat.

Fig 3. 200 dia.s



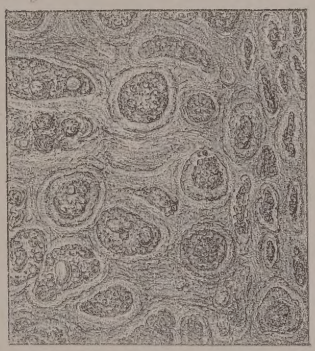
Mouse.

Fig 4. 200 dia.s



Rabbit.

Fig 5. 200 dia.s



Whale.

Fig 6. 200 dia.s

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Elephant.

Fig 7. 200 dia.s

Human.

Fig 8. 200 dia.s

Human.

Fig 9. 200 dia.s

Enchondroma.

Fig 10. 200 dia.s

Enchondroma.

Fig 11. 200 dia.s

Enchondroma.

Fig 12. 200 dia.s

S.W. Leonard. del. et lith.

1000 ths of an Inch.

PLATE VIII.

Fig. 1. A vertical section of the cartilaginous epiphysis of the head of the humerus of a Human fœtus of seven months, exhibiting large blood-vessels running in canals in its interior.

Fig. 2. Canals from the same, more highly magnified, in which the inclosed blood-vessels are plainly shown.

Fig. 3. A vertical section of the head of a tibia of a Human fœtus, with the epiphysis attached. *a*. Articular vessels entering the epiphysis. *b*. Non-vascular lamella.

Fig. 4. The outer surface of the upper half of a radius of a Human fœtus of seven months. *a*. Vessels of synovial membrane lying upon the cartilaginous epiphysis. *b*. Articular vessels.

Fig. 5. The opposite half of the same radius. *a*. Articular lamella. *b b*. Vessels passing in to supply the cartilaginous epiphysis.

Fig. 6. The glenoid cavity of the right scapula of a Human fœtus of full time, showing the looped vessels of the synovial membrane on its margin. *a*. Synovial gland.

Fig. 7. Vessels of external surface of membraniform cartilage, forming the auricle of the ear of an adult Human subject.

Fig. 8. Synovial vessels of ligamentum teres of a Human fœtus of seven months, none of which enter the cartilage of the head of the femur, but terminate in loops at the point of insertion of the ligament into it.

Fig. 9. The acetabulum, ligamentum teres, and a portion of the head of the femur of the same fœtus, showing the large amount of capillaries in the synovial membrane covering the ligamentum teres, and their termination in loops on the head of the femur. *a*. Synovial vessels in the acetabulum.

Fig. 10. Highly magnified representation of looped capillaries of synovial membrane, from the margin of the glenoid cavity, represented in Fig. 6.

Fig. 11. A vertical section of diseased articular cartilage, largely supplied with blood-vessels.

HISTOLOGY OF ANIMALS.

VESSELS OF CARTILAGE.

Plate VIII.

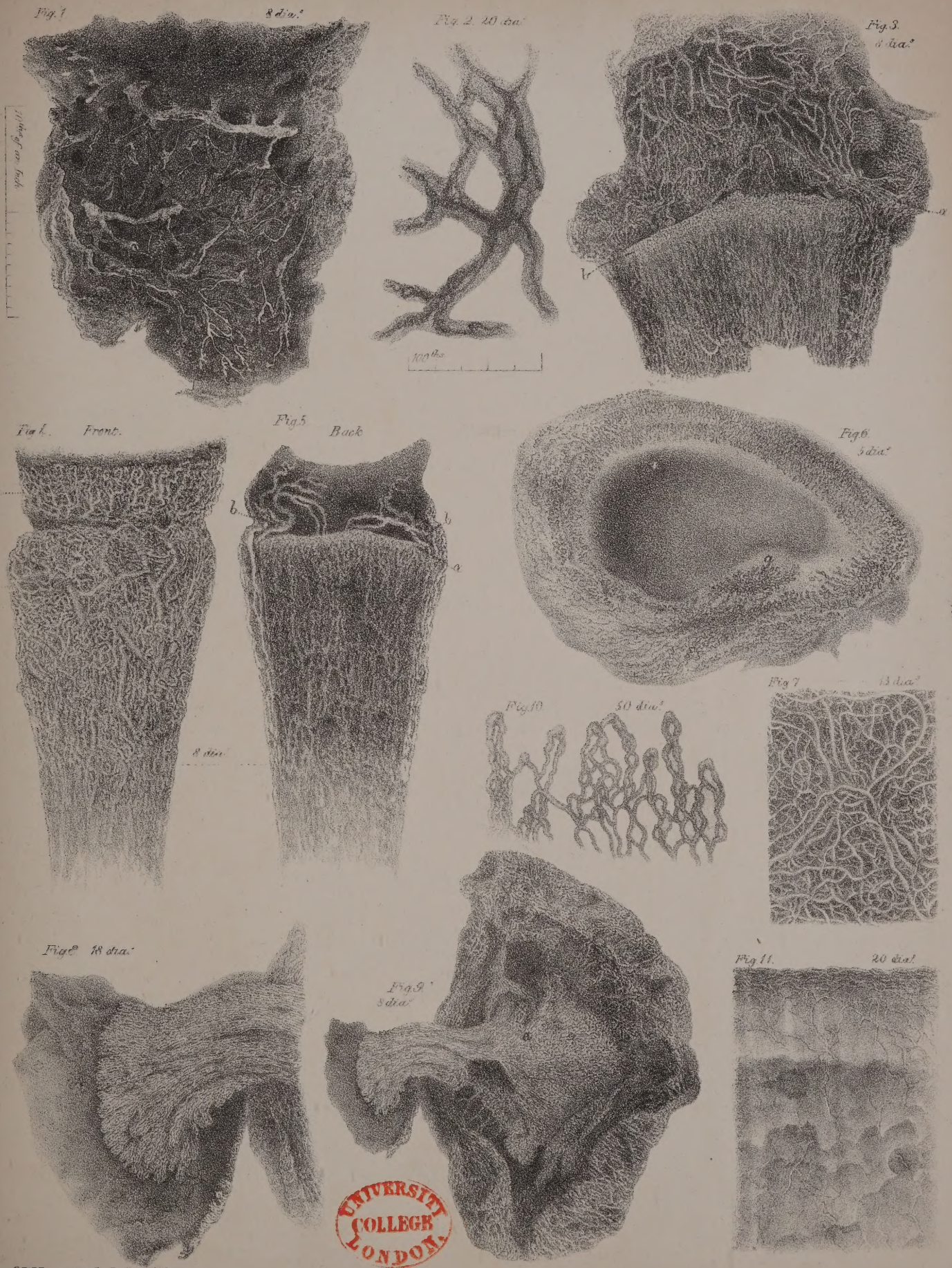

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PLATE IX.

Fig. 1. A portion of a lobule of adipose tissue from an adult Human subject, in which the cells are of polygonal figure.

Fig. 2. An isolated cell from the same lobule, of spherical figure.

Fig. 3. Oil-globules from the liver of a Cod-fish, *Gadus Morrhua*.

Fig. 4. Adipose cells from an old Woman, showing crystals in their interior.

Fig. 5. Capillaries of a small lobule of adipose tissue from the Human subject.

Fig. 6. Capillaries of a small lobule of adipose tissue from pleura costalis of Human fœtus of full time, highly magnified to show their looped arrangement around the cells.

Fig. 7. Pigmentum nigrum from the eye of a Sheep, *Ovis aries*.

Fig. 8. Pigmentum nigrum from the eye of a Porpoise, *Phocæna communis*.

Fig. 9. Pigmentum nigrum from the eye of an adult Human subject.

Fig. 10. Pigmentum nigrum from the eye of a Human fœtus of six months. *a a*. Nuclei of the cells.

Fig. 11. Another portion of the same, more highly magnified. *a a*. Nuclei of the cells.

Fig. 12. Pigmental surface of the cuticle of a Negro.

Fig. 13. A portion of the same pigment more highly magnified.

Fig. 14. Pigment cells of peculiar figure from the choroid of a Sheep, each exhibiting a central transparent nucleus, as at *a*.

Fig. 15. Stellate pigment cells from the skin of a Lamprey, *Petromyzon marinus*.

Fig. 16. Vertical section of articular cartilage from the distal extremity of the first phalanx of the great toe of an old Woman. *a*. Non-vascular lamella. *b*. Bone of the shaft. *c*. Cartilage cells having their long diameters in the direction of that of the shaft of the bone. *d*. Cartilage cells flattened and having their long diameters in the direction of the articular surface.

Fig. 17. Cells of articular cartilage in a vertical section of the head of a femur of an Emeu, *Dromaius Novæ-Hollandiæ*.

Fig. 18. The upper portion of the same section, showing the thick stratum of fibro-cartilage.

Fig. 19. A transverse section of articular cartilage from the head of a femur of an Albatros, *Diomedea exulans*, showing the cartilage cells surrounded by interlacing fibres.

Fig. 20. A transverse section of articular cartilage from the ball of a vertebra of a Boa, *Python Tigris*, showing large compound cartilage cells on its free surface.

Fig. 21. The surface of a portion of articular cartilage from the head of a humerus of a Woman aged 19, showing numerous nucleated cartilage cells.

Fig. 22. The surface of a portion of articular cartilage from the head of a humerus of an old Woman, showing large cartilage cells with only a faint trace of nuclei.

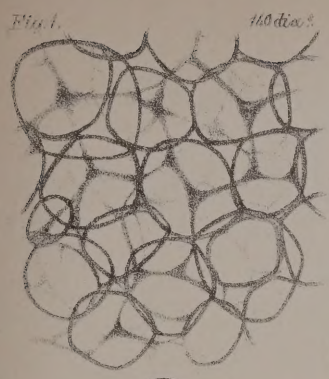
Fig. 23. A vertical section of the articular cartilage from the lower end of the femur of a fœtal Wolf, showing the cells arranged in columns prior to becoming ossified, and the canals for the passage of large blood-vessels.

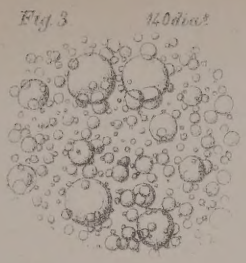
HISTOLOGY OF ANIMALS,

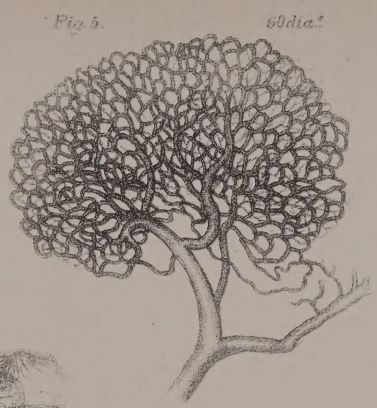
ADIPOSE TISSUE,

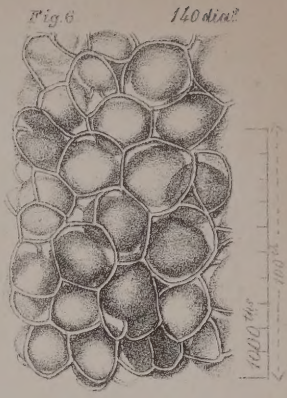
PIGMENT, AND ARTICULAR CARTILAGE.

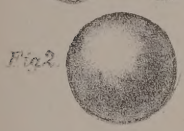
Plate IX.

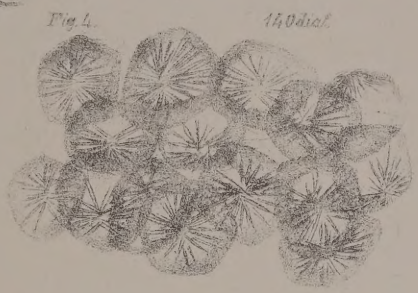


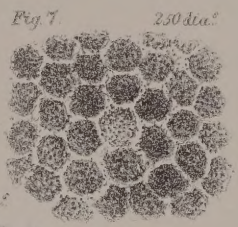


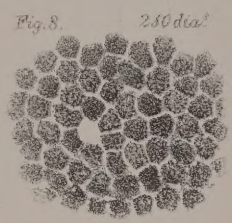


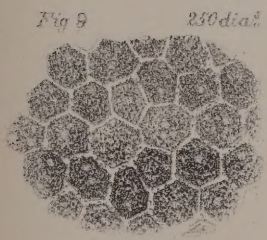


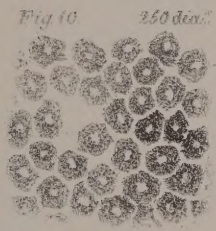


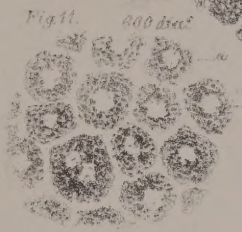


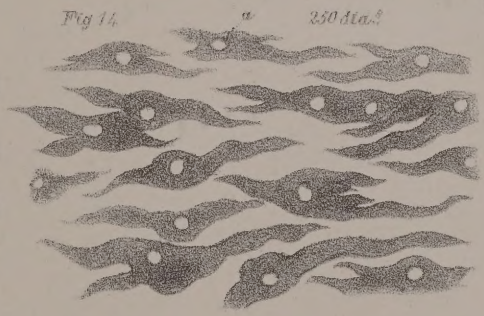


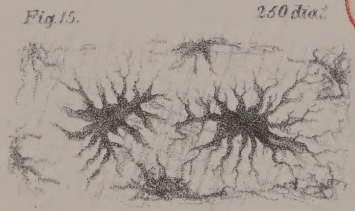












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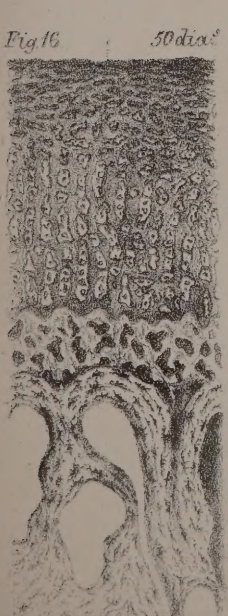

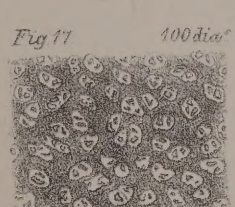

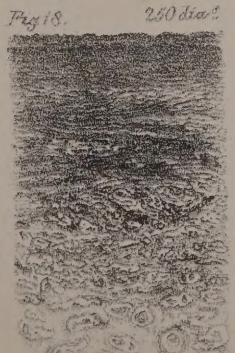

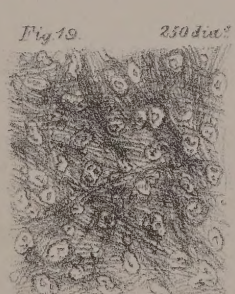

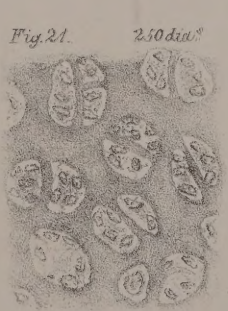

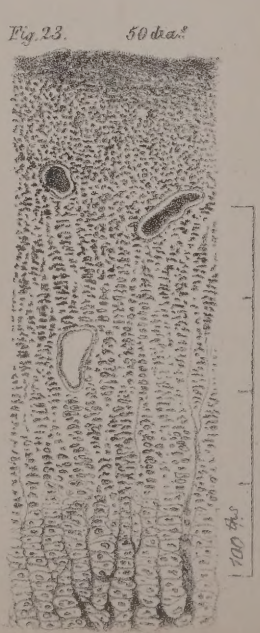

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PLATE X.

Fig. 1. A portion of siliceous cuticle from the stem of *Equisetum hyemale.*

Fig. 2. Siliceous cuticle from leaf of a Bamboo, *Bambusa minor.* *a.* A small cup thoroughly decarbonized. *b.* Another cup partially decarbonized.

Fig. 3. A portion of the siliceous cuticle of a Dragon Cane.

Fig. 4. A portion of the siliceous cuticle of the stalk of Wheat, composed of elongated cells with indented edges. *a.* Remains of the fibre of a large spiral vessel.

Fig. 5. A portion of the siliceous cuticle of a Grass, *Pharus cristatus.* *a a.* Peculiar shaped bodies like the thickened fibres of annular vessels. *b.* Stellate bodies resembling raphides.

Fig. 6. Siliceous cuticle of a Grass, *Festuca pratensis,* exhibiting large cups. *a.* The appearance presented as an opaque object under a magnifying power of 100 linear. *b.* A portion of the same, viewed as a transparent object under a power of 500 linear.

Fig. 7. Cuticle from the under surface of the leaf of *Deutzia scabra,* exhibiting two stellate hairs and numerous flattened cells, all of which are composed of silica.

Fig. 8. Siliceous cuticle of a Manilla Cane.

Fig. 9. Siliceous cuticle of a Malacca Cane.

Fig. 10. Skeleton of Sponges. *a.* Portion of a large horny fibre enclosing a bundle of small siliceous spicula. *c.* A short branch having one spiculum only. *d.* A portion of the horny skeleton of a fine variety of Turkey Sponge.

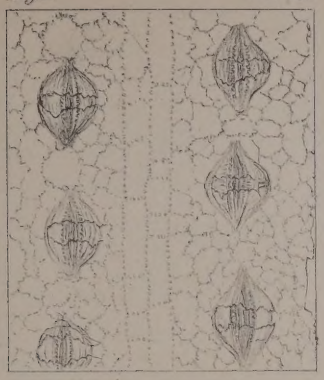
Fig. 11. Skeleton of Sponges. *a.* Siliceous skeleton of a gemmule of an undescribed species of Sponge. *b.* Another form of gemmule from the same sponge. *c.* Large horny fibres of a sponge of the genus *Verongia.* *d.* Tube of the fibre. *e, f.* Spicula of peculiar figure from undescribed species of Sponge. *g.* Perforation of the gemmule.

Fig. 12. Skeleton of Sponges. *a.* Tri-radiate spiculum of a Sponge covered with annular elevations. *b.* Spiculum of the acerate form, covered with rows of spines. *c.* Spiculum of the acerate form covered with tubercles. *d.* Curvate spiculum. *e.* Portion of a large spiculum showing the central gravity and concentric rings of growth. *f.* Bicurvate spiculum.

HISTOLOGY OF ANIMALS.

STRUCTURE OF THE SKELETON IN VEGETABLES AND ANIMALS.

Fig. 1. 130 dias



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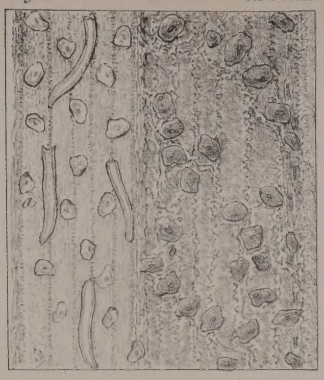

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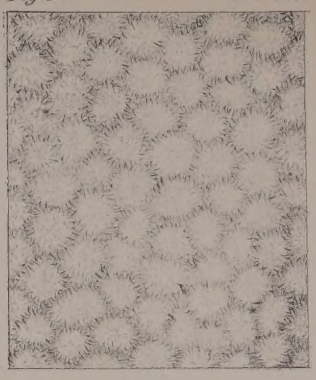

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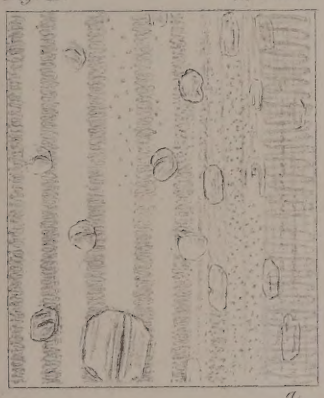

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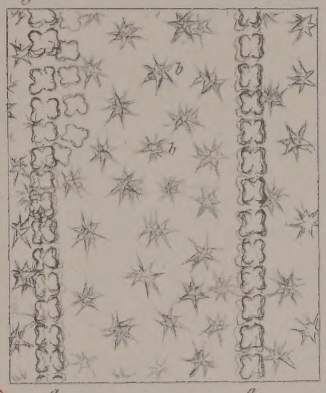

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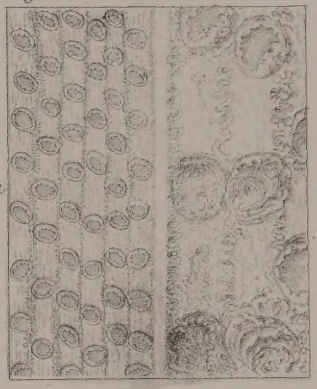

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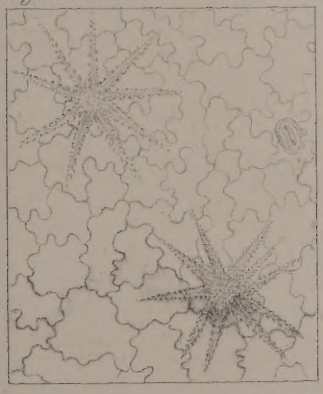
Fig. 7. 130 dias



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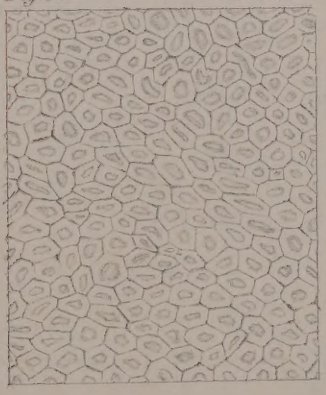

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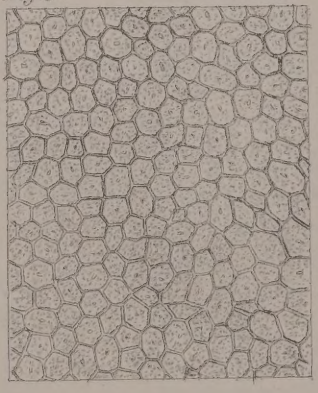
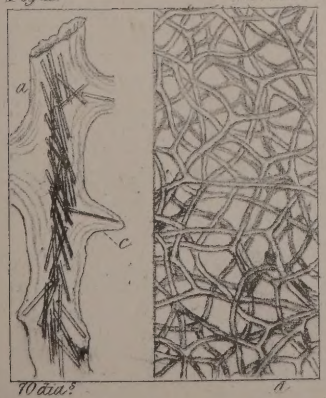


Fig. 10 25. dias



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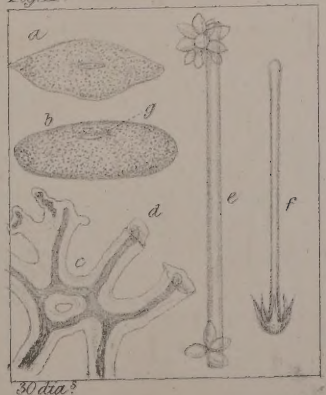

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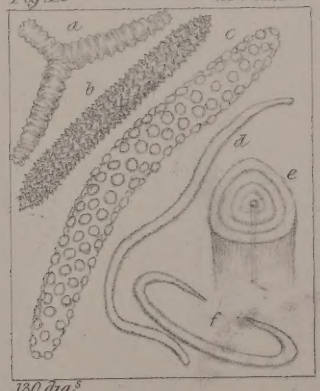

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PLATE XI.

Fig. 1. A portion of a Sponge, *Halichondria simulans*, showing siliceous spicula supported by a soft horny material.

Fig. 2. A portion of the same Sponge, showing the spicula *in situ*, the horny matter having been rendered transparent by Canada balsam.

Fig. 3. Acerate spicula from the same Sponge.

Fig. 4. Spicula of Sponges. *a*. Acuate spiculum. *b*. Acuate spicula covered with spines. *c c*. Spinulate spicula.

Fig. 5. Acuate spicula covered with spines.

Fig. 6. Spicula of Sponges. *a a*. Acuate spicula covered with spines arranged in rings. *b, c*. Other varieties of spicula from the same Sponge.

Fig. 7. Spicula of Sponges. *a a*. Curved spinulate spicula. *b b*. Conical spicula covered with spines arranged in rings. *c c*. Clavate spicula covered with short spines.

Fig. 8. Spicula of Sponges. *a*. Large tri-radiate spiculum. *a'*. Smaller tri-radiate spiculum. *b*. Large tri-radiate spiculum. *c c*. Small tri-radiate calcareous spicula from a Sponge of the genus *Grantia*. *d*. Quadri-radiate spiculum. *e*. Curved acerate spiculum. *f*. Multi-radiate spicula.

Fig. 9. Spicula of Sponges. *a*. Biclavate spiculum. *b*. Double recurvo-ternate spiculum. *c, d*. Expando-ternate spicula. *e*. Dichotomo-expando-ternate spiculum. *f*. Recurvo-ternate spiculum. *g g*. Flecto-spinulate spicula. *h*. Ventricose spicula. *i i i*. Spinulate spicula.

Fig. 10. Gemmules of Geodia. *a, c, d, e, i*. Gemmules in early stages of development. *b, g*. The same, in the adult condition. *f, h*. Abnormal forms.

Fig. 11. Double bi-ternate spicula.

Fig. 12. Sphero-stellate spicula of *Tethea*. *a*. Three specimens magnified 100 diameters. *b*. One of the same magnified 250 diameters.

Fig. 13. Sphero-stellate spicula of *Tethea*.

Fig. 14. Stellate spicula from a tunicated Mollusk.

Fig. 15. Tricuspid anchorate spicula.

Fig. 16. Gemmule of *Spongilla fluviatilis* enclosed in a framework of spicula.

Fig. 17. Gemmules of an undescribed species of Sponge, probably of the genus *Pachymatisma*.

Fig. 18. A portion of the surface of one of the same gemmules, more highly magnified.

Fig. 19. Gemmule of *Spongilla fluviatilis*, treated with acid in order to show its coating of bi-rotulate spicula.

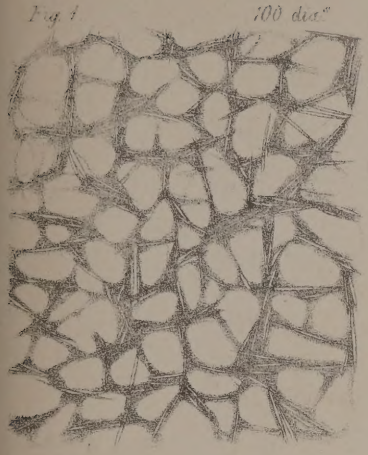
Fig. 20. Bi-rotulate spicula of *Spongilla fluviatilis*. *a*. End view of three spicula. *b*. A portion of a row of the same seen edgeways.

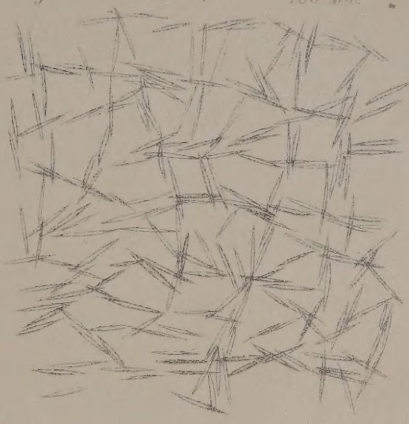
Fig. 21. Five bi-rotulate spicula, magnified 600 diameters.

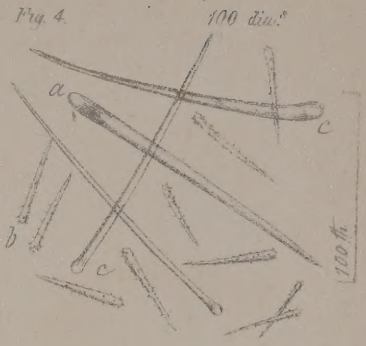
HISTOLOGY OF ANIMALS.

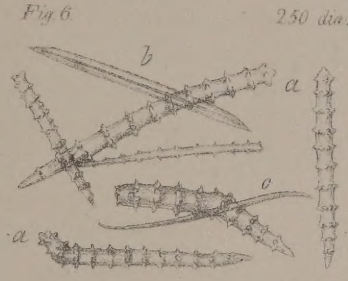
SKELETON OF SPONGES.

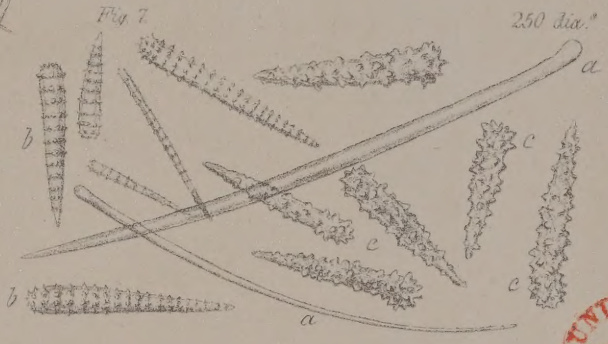
Plate. XI.

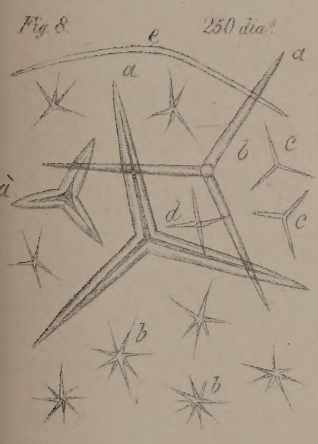


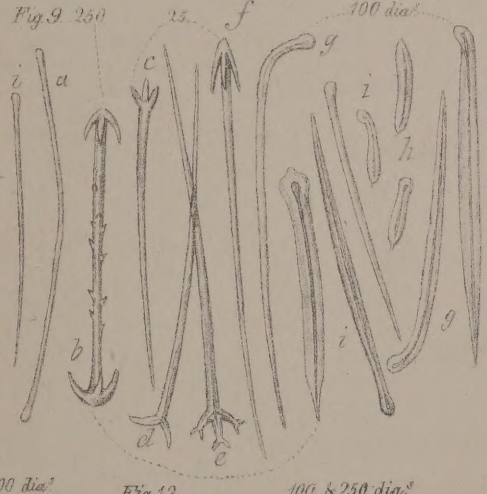


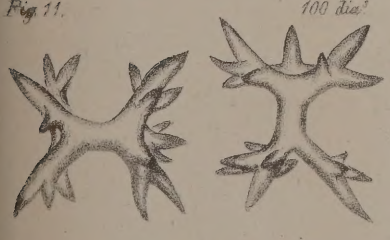


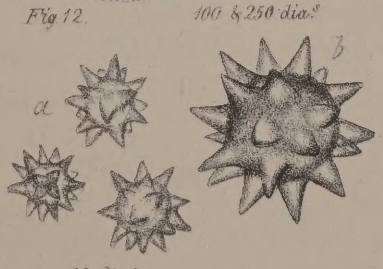


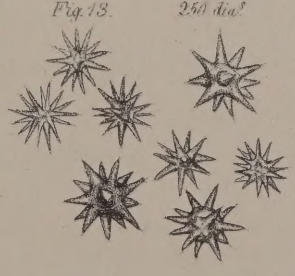


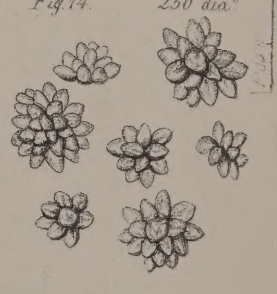


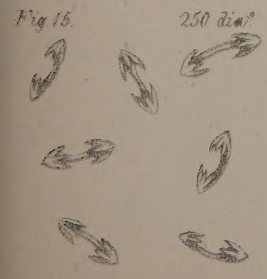


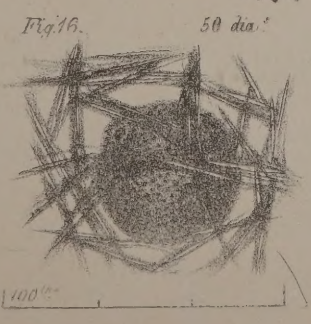


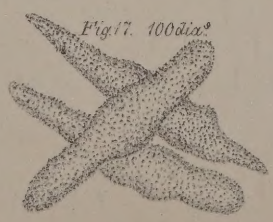


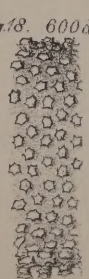


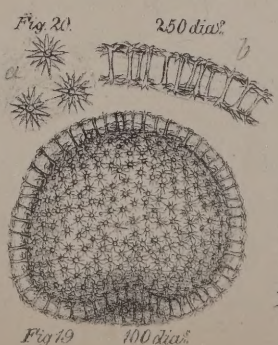












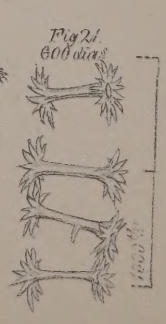


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PLATE XII.

Fig. 1. Naviculæ. *a. Navicula grandis. b. Navicula viridis.*

Fig. 2. *Meridion circulare. a.* Loricæ arranged in a circular and spiral form. *b.* Five loricæ more highly magnified.

Fig. 3. Two specimens of *Biddulphia pulchella* in an old case.

Fig. 4. Recent specimens of *Gomphonema geminatum,* attached to horny stalks.

Fig. 5. Fossil *Eunotia* of undescribed species, found in earth from Bermuda.

Fig. 6. Loricæ of *Cocconema lanceolatum.*

Fig. 7. Loricæ of *Cocconema Boëckii.*

Fig. 8. Recent specimens of *Achnanthes longipes.*

Fig. 9. Loricæ of *Amphitetras antediluviana. a.* Entire specimen. *b, c.* Upper and under surface of the two lateral portions.

Fig. 10. Attached and separated joints of *Gallionella sulcata.*

Fig. 11. Four specimens of *Isthmia enervis.*

Fig. 12. *Isthmia obliquata.*

Fig. 13. Loricæ of *Diatoma flocculosum* in an early stage.

Fig. 14. Loricæ of *Diatoma flocculosum* in the fully developed stage. *a.* Loricæ of *Diatoma elongatum.*

Fig. 15. Ribbon-like filaments of *Fragillaria pectinalis.*

Fig. 16. A peculiar form of *Coscinodiscus,* found in earth from Bermuda.

Fig. 17. One of the loricæ of an *Actinocyclus* from Bermuda.

Fig. 18. A portion of one of the loricæ of a *Coscinodiscus* from Bermuda.

Fig. 19. Loricæ of a species of *Cocconeis* from Algoa Bay. *a, b.* Two specimens magnified 100 diameters. *c.* Another magnified 500 diameters.

Fig. 20. Loricæ of *Campylodiscus clypeus.*

Fig. 21. A lorica of *Arachnoidiscus Moxhayi.*

Fig. 22. Loricæ of five species of *Triceratium. a. T. favus* from Thames mud. *b.* Small species from Bermuda earth, with one margin curved. *c.* Small species from Bermuda earth, with its three margins curved. *d.* Another species from Bermuda earth, very much resembling a triradiate spiculum of sponge. *e.* A larger species, also from Bermuda, having its angles produced in the form of spines.

Fig. 23. A specimen of *Dictyocha fibula* from Bermuda earth. *a, b.* Other specimens in the same slide.

Fig. 24. A specimen of *Zygoceros rhombus.*

Fig. 25. A peculiar form of siliceous lorica like that of a Navicula, found in earth from Piscataway, Maryland.

Fig. 26. A peculiar species of Navicula from New Plymouth, New Zealand.

HISTOLOGY OF ANIMALS, SKELETON OF INFUSORIA.

Plate XII.

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PLATE XIII.

Fig. 1. A transverse section of a Gorgonia, *G. petechialis*. *a*. Spicula of crust. *b*. Spicula in the central portion. *c*. Two spicula separated from the crust. *d*. Three spicula detached from the centre. *e*. Two other forms of spicula, occasionally found in the same zoophyte.

Fig. 2. Spicula of *Gorgonia umbraculum*. *a*. Large angular specimen from the outer surface of the crust. *b*. Two smaller specimens from nearer the centre.

Fig. 3. Four spicula from the fleshy crust of *Melitæa elongata*.

Fig. 4. Spicula of an undescribed species of Gorgonia. *a*. Four specimens from the centre. *b*. A single spiculum from the outer portion of the crust.

Fig. 5. Five spicula of *Gorgonia elongata*, curved, and having tubercles from one side only.

Fig. 6. Three spicula of large size of an Alcyonium from the Navigators' Islands.

Fig. 7. Three spicula of *Alcyonium digitatum*.

Fig. 8. A portion of the shell of a fossil Star-fish, *Pentagonaster*.

Fig. 9. Three spicula from the fleshy crust of *Isis Hippuris*.

Fig. 10. A portion of the horny skeleton of a *Campanularia*.

Fig. 11. A portion of the bony stem of *Virgularia mirabilis*.

Fig. 12. A transverse section of a branch of a Myriapore, *Nullipora alciformis*.

Fig. 13. Calcareous spicula from the lower portion of the stem of *Pavonaria quadrangularis*.

Fig. 14. A segment of a transverse section of the horny stem of *Gorgonia ceratophyta*.

Fig. 15. A portion of the calcareous skeleton of an Echinoderm, found in Ichaboe Guano.

Fig. 16. A portion of the calcareous skeleton of a large Star-fish, *Asterias echinites*.

Fig. 17. A portion of one of the antennæ of a male Cockchafer, *Melolontha vulgaris*, exhibiting a cellular structure.

Fig. 18. A portion of the horny skeleton of a larva of *Hidrous piceus*, composed of nucleated cells.

Fig. 19. A segment of a transverse section of the stem of *Gorgonia Americana*, exhibiting masses of calcareous matter imbedded in a horny substance.

Fig. 20. A segment of a transverse section of the horny stem of *Antipathes spiralis*, exhibiting radiating and circular fibres of large size and dark brown colour.

Fig. 21. A portion of the shell of a large Shrimp, *Crangon vulgaris*.

Fig. 22. A portion of the carapace of a small Crab, composed of hexagonal cells of horny matter.

Fig. 23. A portion of a transverse section of a branch of a Nullipore, *Millepora informis*.

Fig. 24. A spiculum from the outer surface of a Sea-pen, *Renilla Americana*.

Fig. 25. A transverse section of a portion of a large claw of a Crab, showing tubular structure and lines of growth.

Fig. 26. A portion of the outer surface of a large Crab, showing the hexagonal cells of the cuticle.

Fig. 27. A portion of the outer surface of the same Crab. *a*. Portion of one of the large papillæ. *b*. The hexagonal cells of the cuticle.

Fig. 28. Tubuli in a transverse section of one of the large claws of the same Crab, giving off lateral branches.

Fig. 29. Tubular structure seen in a transverse section of one of the large claws of the same Crab.

Fig. 30. A portion of one of the tail plates of a Lobster, *Astacus marinus*. *a*. Hexagonal cells of the cuticle. *b*. Angular form of some of the calcareous granules.

HISTOLOGY OF ANIMALS.

SKELETON OF ZOOPHYTES, INSECTS, AND CRUSTACEA.

Plate XIII.

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Lens Aldous, Lithe.

Day & Son, Lith.rs to The Queen.

PLATE XIV.

Fig. 1. A segment of a transverse section of a spine of a large Star-fish, *Asterias echinites.*

Fig. 2. A transverse section of a portion of the shell of an *Echinus.*

Fig. 3. A transverse section of a portion of the shell of a *Spatangus.*

Fig. 4. A vertical section of the shell of an *Echinus,* made through one of the large tubercles.

Fig. 5. A segment of a transverse section of a spine of a Star-fish of the genus *Astropecten.*

Fig. 6. A portion of calcareous matter from the margin of one of the tentacles of a *Holothuria.*

Fig. 7. A horizontal section of one of the flattened spines of *Echinus atratus.* *a.* Perforations on upper surface. *b.* Perforations and reticulations in the layer beneath.

Fig. 8. A vertical section of a spine of a small *Cidaris.*

Fig. 9. A small spine from the outer surface of an *Ophiura.*

Fig. 10. A vertical section of a small spine of an *Echinus.* *a.* Base. *b c, d e, f g.* Lines indicating the direction in which sections have been made.

Fig. 11. A segment of a transverse section of a spine of an *Echinus.* *a a.* The pillars.

Fig. 12. A calcareous disc taken from the extremity of one of the tentacles of a *Holothuria, H. frondosa.* *a.* A portion of the margin of the same, more highly magnified.

Fig. 13. Spicula of a horny nature, obtained from one of the tubercles of an *Actinia, A. mesembryanthemum.*

Fig. 14. A portion of the coarse reticulated tissue from the centre of a spine of a large *Echinus.*

Fig. 15. A segment of a transverse section of a spine of an undescribed species of *Echinus,* exhibiting a beautiful reticulated structure.

Fig. 16. A segment of a transverse section of a spine of a small species of *Cidaris,* exhibiting a broad semi-opaque margin with tubes running through it.

Fig. 17. A portion of the calcareous framework situated around the mouth of a *Holothuria.*

Fig. 18. A segment of a transverse section of a spine of a larger *Cidaris,* exhibiting a semi-opaque margin, and the arched form of the reticulations near the centre.

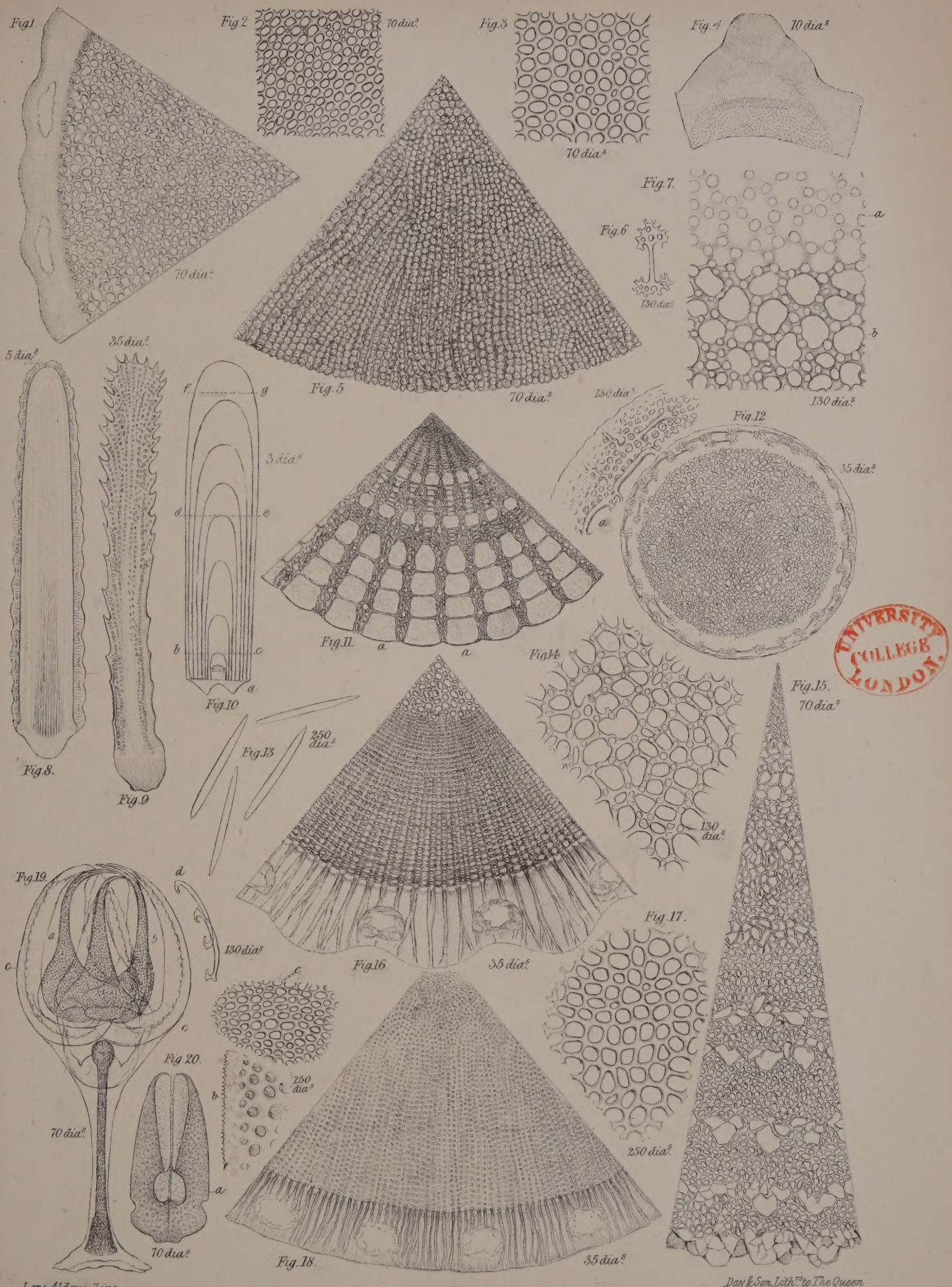
Fig. 19. One of the *Pedicellariæ* from the upper surface of *Echinus miliaris.* *a, b.* Calcareous jaws. *c c.* Rows of spicula. *d.* Two of the same spicula more highly magnified.

Fig. 20. Calcareous skeleton of *Pedicellaria* of *Asterias rubens.* *a.* Two perfect valves. *b, c.* Two portions of the same more highly magnified.

HISTOLOGY OF ANIMALS.

SKELETON OF ECHINODERMATA.

Plate XIV.



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Lens Aldous, Zinc.

Day & Son, Lith.rs to The Queen

PLATE XV.

Fig. 1. A transverse section of a joint of the stem of a recent Pentacrinite, *Pentacrinus Caput Medusæ*, magnified 2 diameters. *a*. A portion of the centre of one of the rays, magnified 200 diameters.

Fig. 2. A segment of a transverse section of the same Pentacrinite.

Fig. 3. A segment of a transverse section of a joint of the stem of a fossil *Pentacrinite*. *a*. The entire specimen, magnified 2 diameters. *b*. A portion of the same, magnified 200 diameters.

Fig. 4. A segment of a transverse section of a joint of the stem of a fossil *Encrinite*. *a*. The entire section, magnified 2 diameters. *b*. A portion of the same, magnified 200 diameters.

Fig. 5. A vertical section of the shell of a Cray-fish, *Palinurus vulgaris*.

Fig. 6. A portion of one of the swimming feet of a small Crab, showing the deposition of calcareous matter in an annular form.

Fig. 7. A portion of the cuticular layer of a large Crab, *Cancer pagurus*.

Fig. 8. A portion of the external surface of the shell of a large Crab, *Cancer pagurus*.

Fig. 9. A segment of a transverse section of the spine of a small *Echinus*, exhibiting a reticulated structure over some of the pillars.

Fig. 10. A portion of the cuticular layer of a Cray-fish, *Palinurus vulgaris*.

Fig. 11. A vertical section of the shell of the same Cray-fish, having the calcareous element removed.

Fig. 12. A portion of the shell of a small Crab, exhibiting the cuticular layer and the granules beneath it. *a*. Cuticle. *b*. Granules below the cells. *c*. Granules in the cells.

Fig. 13. A transverse section of one of the claws of a King Crab, *Limulus Polyphemus*.

Fig. 14. A portion of the same claw, exhibiting large tubuli running through it.

Fig. 15. A portion of the new shell of a River Cray-fish, *Astacus fluviatilis*.

Fig. 16. A portion of the cuticular layer of the new shell of the same Cray-fish, showing hexagonal cells and crystals.

Fig. 17. A portion of a horizontal section of one of the large claws of a Crab, showing the ends of the tubuli.

Fig. 18. A portion of a vertical section of a spine of *Echinus trigonarius*, in process of repair after fracture. *a*. The original structure of the spine. *b*. The new portion. *c c*. The line of demarcation between the new and the old structures. *d*. The end of the spine of the natural size.

Fig. 19. A portion of the shell of a Cray-fish, *Astacus fluviatilis*, showing interlacing fibres.

HISTOLOGY OF ANIMALS.

Plate XV.

SKELETON OF ECHINODERMATA, AND CRUSTACEA.

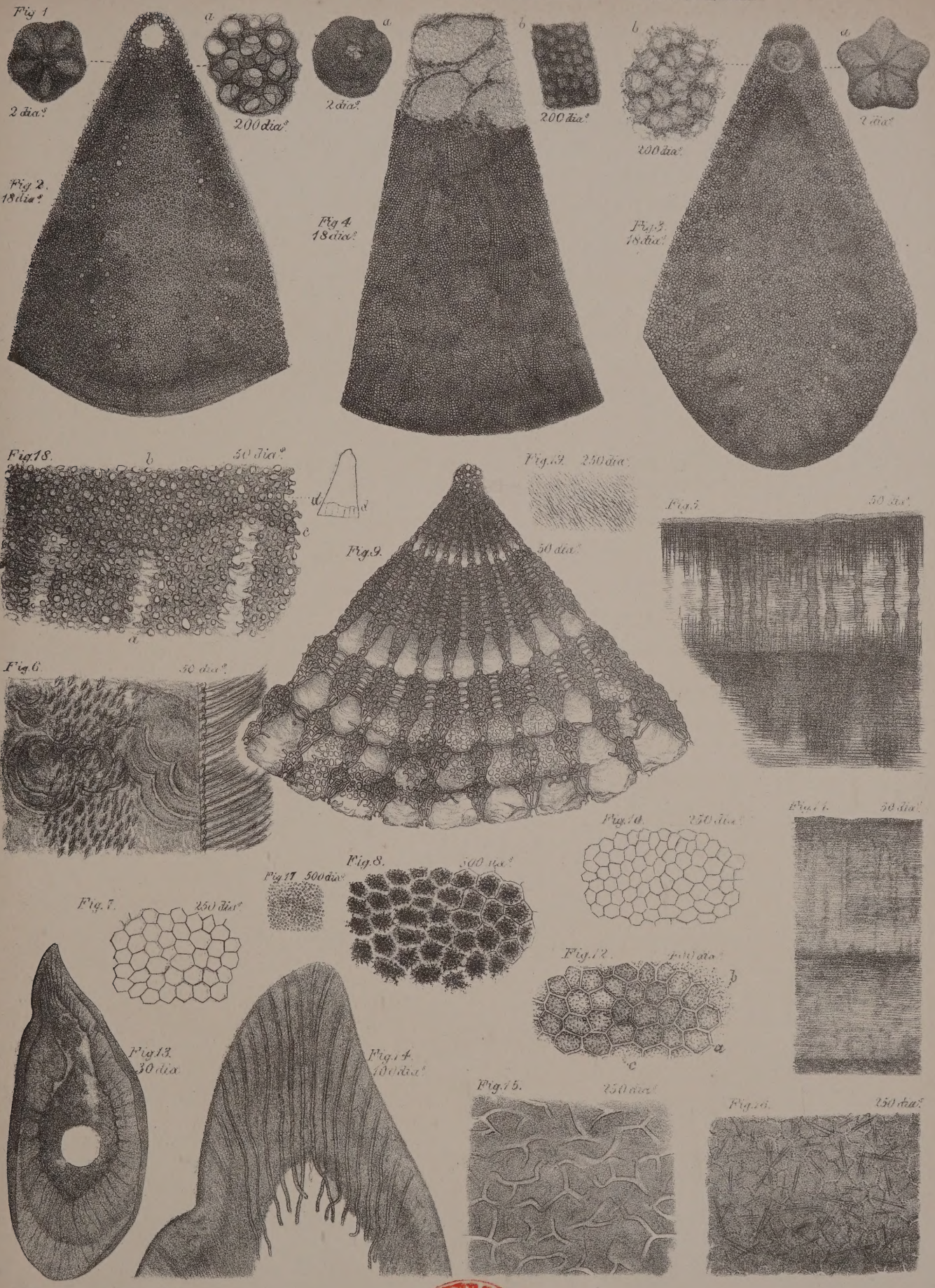

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PLATE XVI.

Fig. 1. A transverse section of the shell of *Pinna nigrina*.

Fig. 2. A vertical section of the shell of *Pinna nigrina*.

Fig. 3. A transverse section of the shell of *Pinna ingens*, showing black cells.

Fig. 4. Prisms of a fossil *Pinna* from the chalk. *a*. A portion of a large prism, showing the transverse striæ. *b*. Portions of three prisms, showing their pointed extremities.

Fig. 5. A portion of the animal basis of *Pinna nigrina*.

Fig. 6. A portion of a horizontal section of the shell of *Avicula margaritifera*, showing large cells in which the transverse striæ are well-marked.

Fig. 7. A horizontal section of the shell of *Terebratula rubicunda*. *a*. Portion of the red outer surface exhibiting perforations and radiating canaliculi. *b*. The internal colourless layer.

Fig. 8. Internal surface of shell of *Terebratula rubicunda*.

Fig. 9. Vertical section of the shell of *Terebratula rubicunda*, showing the course of the perforations.

Fig. 10. Epidermal layer of *Mytilus edulis*.

Fig. 11. Epidermal layer of *Trigonia Lamarckii*.

Fig. 12. Calcareous spicula from the epidermis of a *Doris*.

Fig. 13. Thick-walled cells from the shell of *Ostrea edulis*.

Fig. 14. Crystals of carbonate of lime from outer brown layer of shell of *Ostrea edulis*.

Fig. 15. Fractured edge of the shell of *Cypræa mauritiana*.

Fig. 16. A portion of the surface of the shell of *Lingula anatina*, showing the orifices of tubuli.

Fig. 17. A transverse section of the hinge-tooth of *Pholas crispata*.

Fig. 18. A transverse section of a portion of the shell of *Haliotis splendens*.

Fig. 19. A portion of the inner layer of the shell of *Anomia ephippium*, showing large branching tubuli.

Fig. 20. Vertical section of *Hippurite*.

Fig. 21. Horizontal section of *Hippurite*.

Fig. 22. A vertical section of a *Nummulite*.

Fig. 23. A portion of the vertical section of the same *Nummulite*, more highly magnified.

Fig. 24. A portion of the outer surface of the shell of the same *Nummulite*.

Fig. 25. A horizontal section of the shell of *Haliotis splendens*. *a*. Nacreous layer. *b*. Prisms showing stellate pigment in their interior.

Fig. 26. Vertical section of the lip of the shell of *Unio occidens*, showing that the outer prismatic cellular structure invests the inner nacreous layer.

HISTOLOGY OF ANIMALS
SKELETON OF MOLLUSCA

Plate VI.

Fig. 1. 130 dias

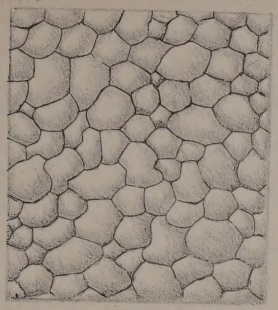


Fig. 2. 130 dias

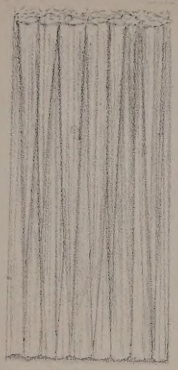


Fig. 3. 130 dias

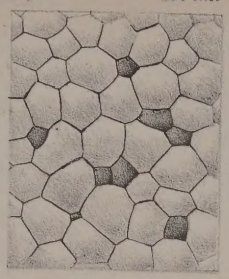
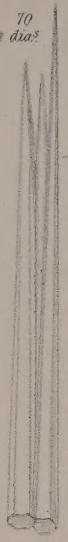


Fig. 4.

250 dias

70 dias



a b

Fig. 5 130 dias

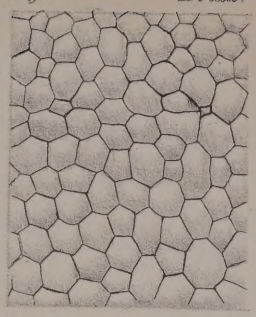


Fig. 11 130 dias

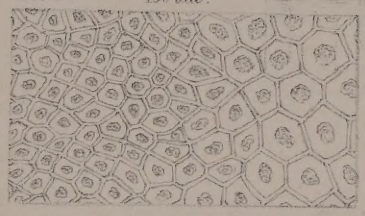


Fig. 10. 130 dias

a

b

Fig. 7. 130 dias

Fig. 6 250 dias

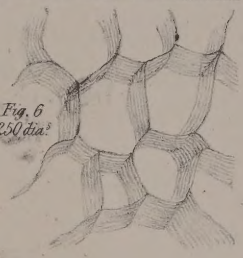


Fig. 8. 130 dias

Fig. 16. 500 dias

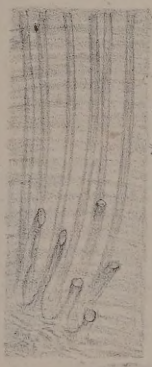


Fig. 9 70 dias

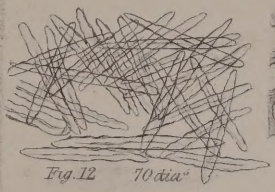


Fig. 12 70 dias

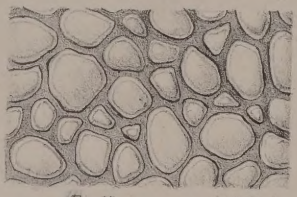


Fig. 13 250 dias

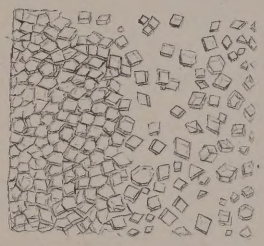


Fig. 14 250 dias

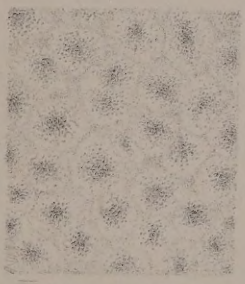


Fig. 17 130 dias

Fig. 18. 70 dias

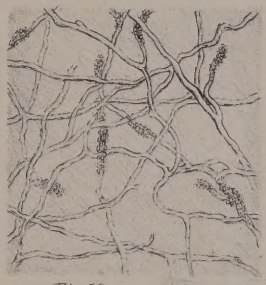


Fig. 19 250 dias

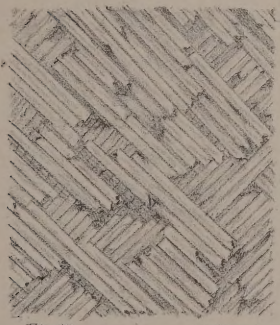
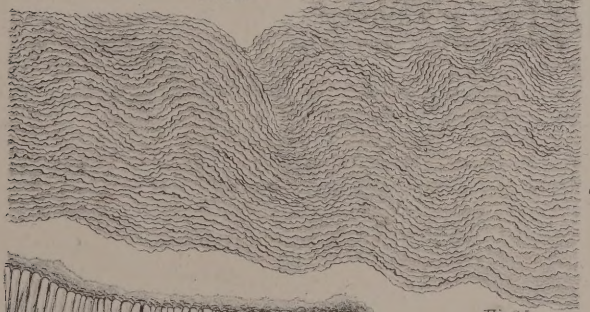


Fig. 15. 250 dias

b



a

Fig. 25. 250 dias

Fig. 26 30 dias

Fig. 20 12 dias

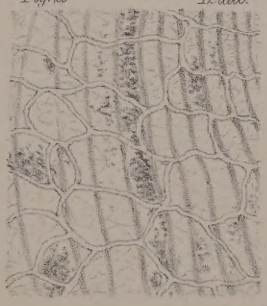


Fig. 23 70 dias

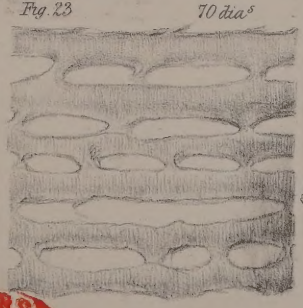


Fig. 21 12 dias

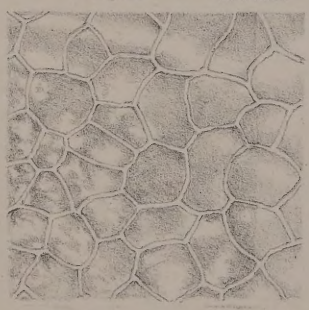


Fig. 22 5 dias

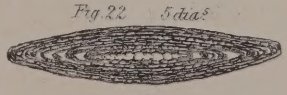


Fig. 24 250 dias

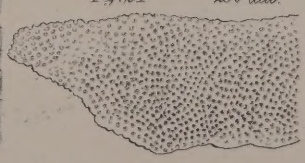


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PLATE XVII.

Fig. 1. A horizontal section of a *Nummulite*.

Fig. 2. A thin layer of the shell of a *Pinna*, showing cells with nuclei.

Fig. 3. A longitudinal section of the shell of *Dentalium entale*.

Fig. 4. A transverse section of a portion of the same shell.

Fig. 5. A portion of the outer decalcified layer of *Terebratula rubicunda*, exhibiting small radiating tubuli attached to the free surface of the cæcal processes lining the perforations of the shell.

Fig. 6. A portion of the outer decalcified membrane of *Terebratula rubicunda*, showing the cæcal tubular processes attached to it.

Fig. 7. A portion of the decalcified membrane from the inner surface of the same shell, showing the openings of the tubular processes upon that surface.

Fig. 8. A horizontal section of the shell of *Atrypa psittacea*, without perforations.

Fig. 9. A fragment of the shell of a fossil *Terebratula, T. inconstans*, without perforations.

Fig. 10. A thin lamina of the shell of an Oyster, exhibiting cells with nuclei.

Fig. 11. A horizontal section of one of the valves of the shell of a Barnacle, *Pollicipes villosus*, exhibiting rows of tubuli.

Fig. 12. A transverse section of the base of the shell of a Barnacle, *Balanus tintinnabulum*, showing a cancellated structure and tubes passing through the walls of the cancelli.

Fig. 13. Calcareous spicula from the outer integument of a Tunicated animal, *Boltenia reniformis*.

Fig. 14. A vertical section of the hinge-tooth of the shell of *Mya arenaria*.

Fig. 15. A horizontal section of the tooth of another specimen of *Mya arenaria*.

Fig. 16. A horizontal section of the tooth of another specimen of *Mya arenaria*.

Fig. 17. A thin lamina of the shell of *Terebratula australis*, showing the splitting up of the middle layer into thin flattened bands or cells.

Fig. 18. Decalcified nacre from the shell of *Haliotis splendens*.

Fig. 19. Decalcified nacre from the shell of *Nautilus Pompilius*, showing a distinctly cellular character.

Fig. 20. A portion of a vertical section of the shell of *Pinna rudis*, showing the splitting up of the prisms into layers of cells.

Fig. 21. Tubular structure of the shell of *Lima scabra*.

Fig. 22. A horizontal section of a portion of one of the calcareous plates from the gizzard of *Bulla lignaria*.

Fig. 23. A portion of the case of an *Annelide*, composed of fragments of silica cemented together by an animal glue.

HISTOLOGY OF ANIMALS,
SKELETON OF MOLLUSCA.

Plate XVII.

Fig. 1. 8 diaˢ

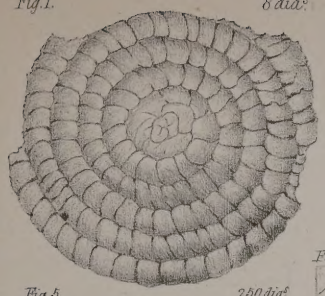


Fig. 2. 300 diaˢ

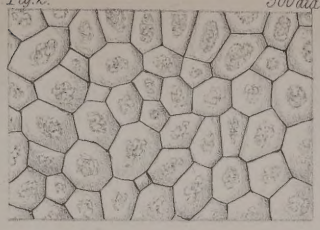


Fig. 3. 70 diaˢ

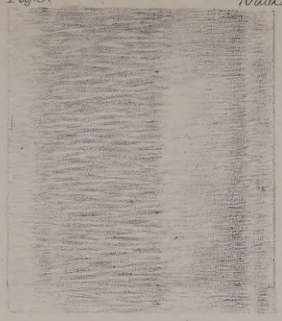


Fig. 4. 35 diaˢ

Fig. 10. 130 diaˢ

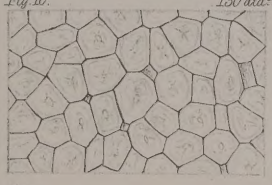


Fig. 5. 250 diaˢ

Fig. 12. 25 diaˢ

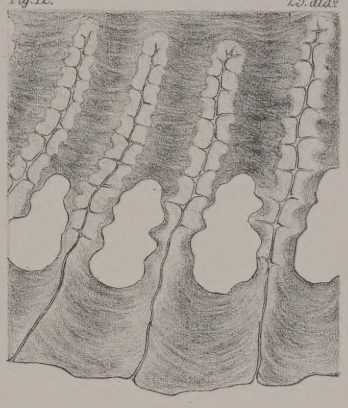


Fig. 11. 35 diaˢ

Fig. 6. 250 diaˢ

Fig. 13. 250 diaˢ

Fig. 7. 130 diaˢ

Fig. 17. 130 diaˢ

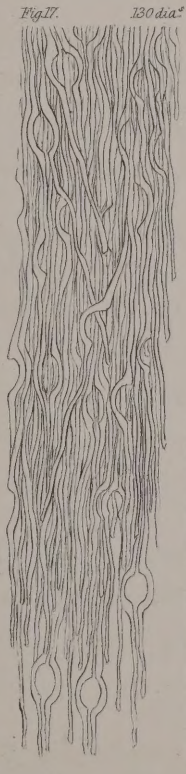


Fig. 14. 130 diaˢ

Fig. 18. 130 diaˢ

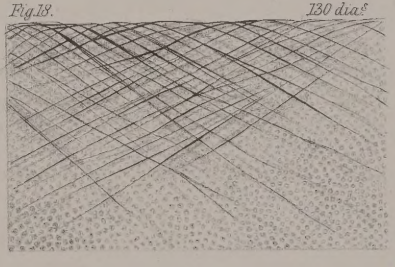


Fig. 8. 130 diaˢ

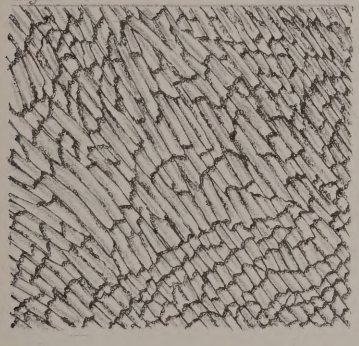


Fig. 19. 500 diaˢ

Fig. 15. 95 diaˢ

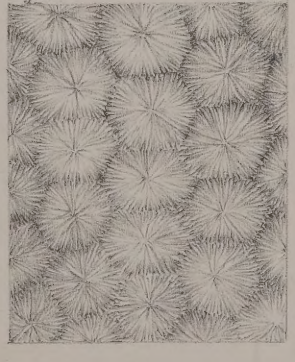


Fig. 9. 130 diaˢ

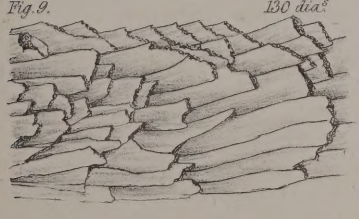


Fig. 16. 130 diaˢ

Fig. 20. 35 diaˢ

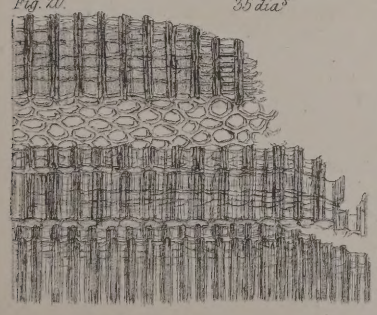


Fig. 21. 250 diaˢ

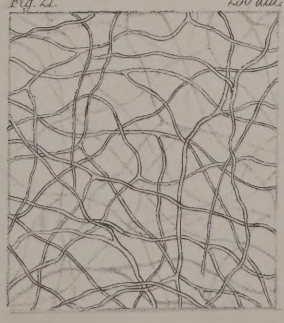


Fig. 23 25 diaˢ

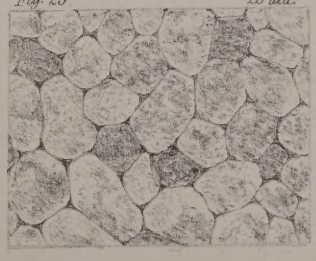
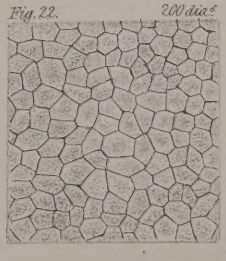


Fig. 22. 200 diaˢ



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Day & Son, lith.rs to the Queen.

PLATE XVIII.

Fig. 1. A segment of a transverse section of a Pearl from an Oyster, *Ostrea edulis*, exhibiting a prismatic cellular structure.

Fig. 2. A portion of the same more highly magnified.

Fig. 3. A portion of a transverse section of a Pearl from an Oyster, in which not only the prismatic structure, but the transverse striæ of the prisms are well shown.

Fig. 4. A segment of a transverse section of another Pearl from an Oyster, in which the prismatic cellular structure is less regular than in Fig. 1.

Fig. 5. A portion of the same Pearl more highly magnified.

Fig. 6. A portion of a section of a true Pearl, exhibiting the lines of nacre.

Fig. 7. A segment of a transverse section of another Pearl, in which the centre presents a cellular structure, and the outside two rings of true pearly matter.

Fig. 8. A portion of the cellular structure of the centre of another Pearl.

Fig. 9. A portion of a horizontal section of a Pearl, in which the cellular structure is nearly obliterated.

Fig. 10. A segment of a transverse section of the "spathose guard" of a *Belemnite*.

Fig. 11. A portion of the same more highly magnified.

Fig. 12. A segment of a transverse section of a small purple Pearl from a species of *Mytilus*.

Fig. 13. A transverse section of the shell of *Nautilus Pompilius*. *a*. Portion of the outer cellular layer, magnified 500 diameters.

Fig. 14. A portion of the outer surface of the shell of *Spirula Australis*. *a*. Entire shell of *Spirula Australis*.

Fig. 15. A portion of the outer hard shell of the *Cuttle-bone* or *Sepiostaire* of *Sepia officinalis*.

Fig. 16. A portion of a transverse section of the same *Sepiostaire*, showing the laminæ and rows of plates.

Fig. 17. One of the plates of the same section magnified 95 diameters, showing its wavy upper surface and its transverse striæ.

Fig. 18. A portion of one of the laminæ of the *Sepiostaire*, showing the shape of the plates as seen when divided transversely.

Fig. 19. A portion of the cellular layer from the internal surface of the shell of *Spirula Australis*.

HISTOLOGY OF ANIMALS.
SKELETON OF MOLLUSCA.

Plate XVIII

Fig. 1. 50 dia.s

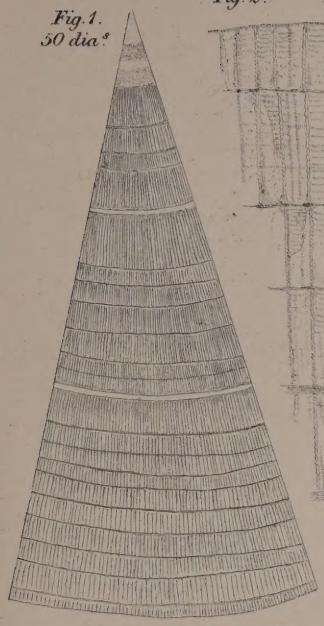
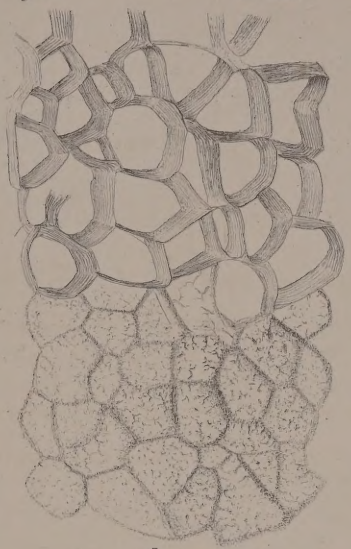


Fig. 2. 250 dia.s

Fig. 3. 250 dia.s



1000ths of an Inch

Fig. 5. 250 dia.s

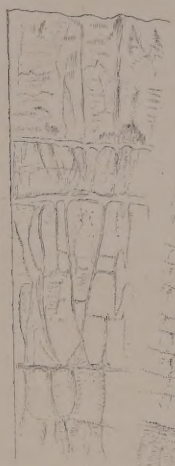


Fig. 4. 30 dia.s

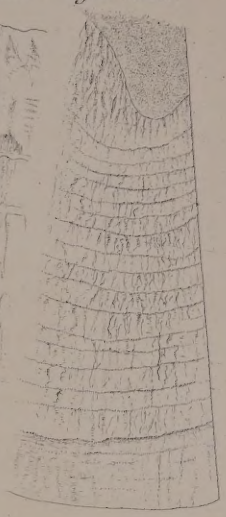


Fig. 6.

500 dia.s

Fig. 7 30 dia.s

Fig. 8. 250 dia.s

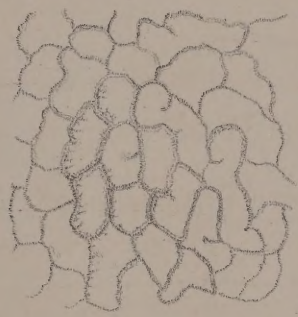
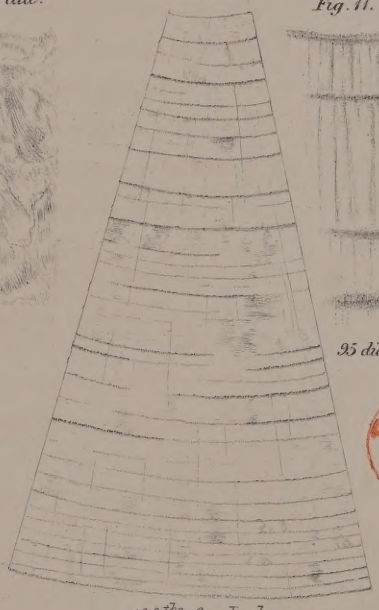


Fig. 9. 30 dia.s

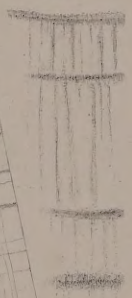
Fig. 10 30 dia.s



100ths of an Inch

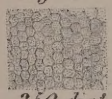
100ths of an Inch.

Fig. 11.



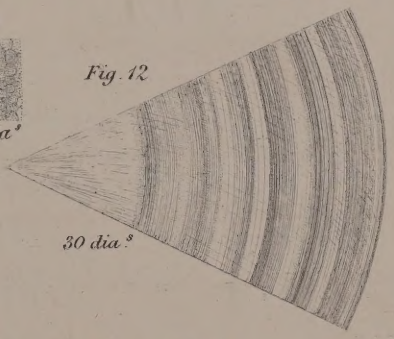
95 dia.s

Fig. 19



250 dia.s

Fig. 12



30 dia.s

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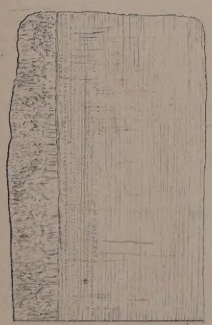
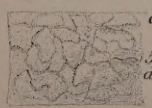
Fig. 16. 50 dia.s

Fig. 13 50 dia.s



a

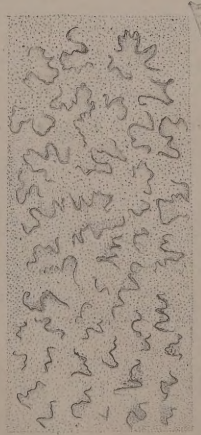


500 dia.s

Fig. 14. 50 dia.s

a

Fig. 18 95 dia.s



1000ths of an Inch

Fig. 17. 95 dia.s

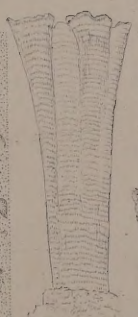


Fig. 15. 50 dia.s

100ths of an Inch

T. S. Ralph, del. & lith.